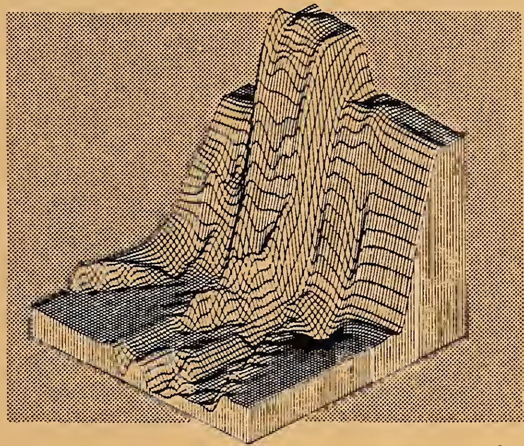
IMSE
FILE COPY
DO NOT TAKE

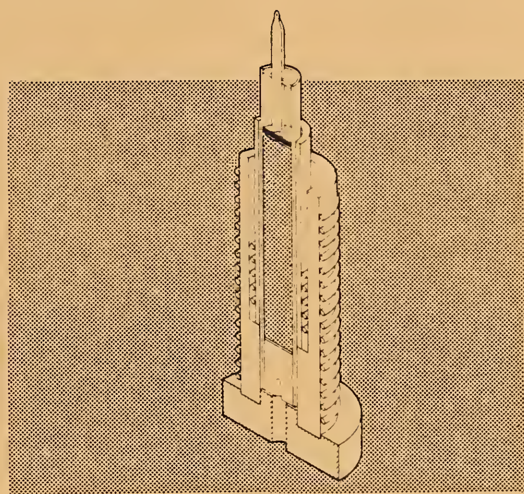
Institute for Materials Science and Engineering

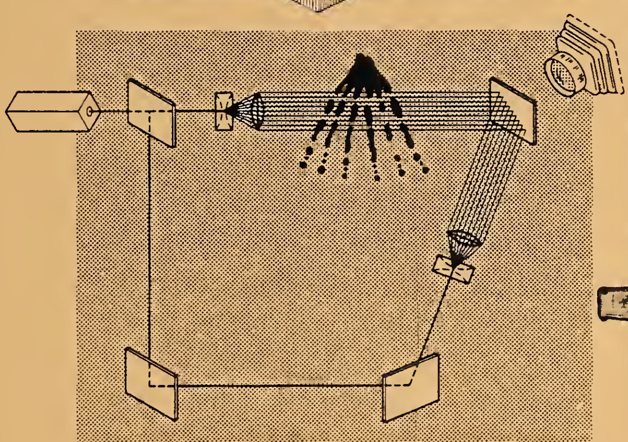
ANNUAL REPORT

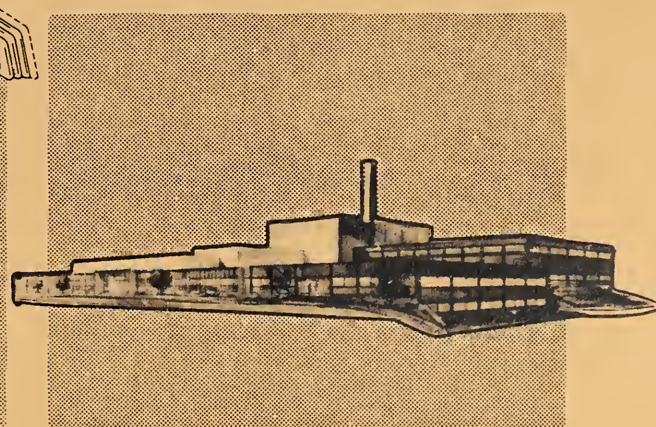
1988

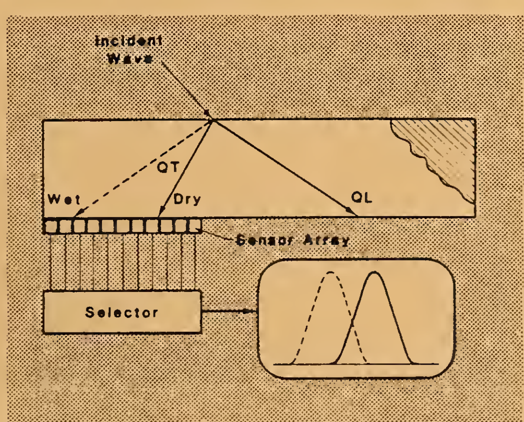
NAS-NRC
Assessment Panel
February 2–3, 1989

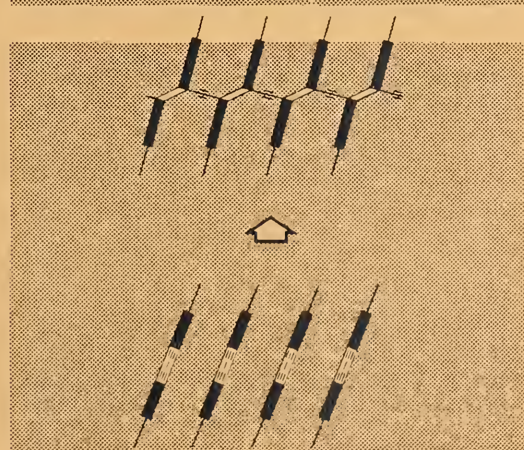












NISTIR 88-3845

U.S. Department of Commerce
National Institute of Standards and Technology

Annual report covers for the operating divisions of the Institute for Materials Science and Engineering and its Office of Nondestructive Evaluation. These annual reports describe in detail the technical activities of each of the Institute's major units and are available on request.

IMSE

Institute for Materials Science and Engineering

ANNUAL REPORT

1988

L.H. Schwartz, Director

U.S. Department of Commerce
National Institute of Standards and Technology

TABLE OF CONTENTS

Agenda

BOARD OF ASSESSMENT PANEL OF NIST PROGRAMS
FOR THE INSTITUTE FOR MATERIALS SCIENCE AND ENGINEERING (IMSE)

Wednesday, February 1, 1989

8:00 p.m.	Get Acquainted Meeting in the Montgomery Room at the Compri Hotel (L. H. Schwartz, H. L. Rook, D. B. Butrymowicz, S. J. Schneider, J. G. Early, and Panel Members), and Charge to Panel	

Thursday, February 2, 1989

8:00 a.m.	Panel meets Compri van in front of Compri Hotel for ride to Administration Building, NIST	
	Lecture Room A	
8:15	Coffee and Doughnuts	Lecture Room A
8:30	Opening Remarks	F. Padovani
8:40	NIST Function and Reorganization - What it means for IMSE	L. Schwartz
9:10	IMSE Overview	L. Schwartz
9:40	Overview of Metallurgy Division Programs	E. N. Pugh
10:00	Discussion of Metallurgy Division Programs	
10:15	Overview of Ceramics Division Programs	S. Hsu
10:35	Discussion of Ceramics Division Programs	
10:50	Break	
11:10	Overview of Fracture & Deformation Division Programs	H. McHenry
11:30	Discussion of Fracture & Deformation Division Programs	
11:40	Travel to Senior Lunch Club	
11:45	Lunch - Dining Room C Panel Members, L. Schwartz, H. Rook, D. Butrymowicz, S. Schneider, and J. Early	

Lecture Room B

12:35 pm	Poster Presentations - Intelligent Processing of Materials		
	o Fluorescence Spectroscopy Probes for Polymer Processing	F. Wang A. Bur	Lecture Room B
	o Optic Fiber Probes for Composites Processing	B. Fanconi	Lecture Room B
	o AC Impedance Spectroscopy for Characterization of Ceramics During Sintering	J. Blendell J. Kelly F. Mopsik E. Fuller, Jr. C.-K. Chiang P. Shull	Lecture Room B
	o Ultrasonic Characterization of Ceramics During Compaction and Densification	J. Kelly G. Blessing M. Jones J. Blendell A. Dragoo E. Fuller	Lecture Room B
	o Formability Sensor for Steel Sheet	A. Clark R. Thompson G. Blessing R. Reno D. Matlock	Lecture Room B
	o Hot-Isostatic Pressing of TiAl	R. Schaefer H. Wadley	Lecture Room B
	o Intelligent Processing of Metal Powders Processing	S. Ridder F. Biancaniello	Lecture Room B
	o Fluid Flow Process	J. Mattingly P. Espina	Lecture Room B
	o Intelligent Control System	T. Hopp S. Osella H. Moncarz	Lecture Room B

Lecture Room A

1:30	Overview of Reactor Radiation Division Programs	M. Rowe
1:50	Discussion of Reactor Radiation Division Programs	
2:05	Overview of Polymers Division Programs	L. Smith

2:25	Discussion of Polymers Division Programs	
2:35	Coffee and soda break	
2:50	Overview of the Office of Nondestructive Evaluation	H. T. Yolken
3:10	Discussion of the Office of Nondestructive Evaluation	
3:20	Summary and General Discussion	L. Schwartz
3:50	Travel to Materials Building	

<u>Materials Building, Room B307</u>

4:00	Executive Session with IMSE Director	
5:15	Panel meets Compri van in front of Materials Building for ride to Compri Hotel	
6:15	Panel meets NIST van in front of Compri Hotel for ride to Flaming Pit Restaurant	
6:30	Social Hour and Dinner - Flaming Pit Restaurant. Division Chiefs, L. Schwartz, H. Rook, D. Butrymowicz, S. Schneider, and J. Early	
9:30	Panel members ride back to Hotel with Division Chiefs	

Friday, February 3, 1989

8:00 a.m.	Panel meets Compri van in front of Compri Hotel for ride to Administration Building, NIST
8:30	Executive Session (Panel Only) - Dining Room C Coffee and doughnuts available before and during the executive session
12:00 p.m.	Lunch with Division Chiefs and L. Schwartz, H. Rook, D. Butrymowicz, S. Schneider, and J. Early - Dining Room C
1:00	Panel Chairman meets with L. Schwartz Materials Building, Room B304
1:15	Panel meets Compri van in front of Administration Building for ride to Compri Hotel
2:00	Panel Chairman meets with Mr. Kammer Administration Building, Room A1134

Panel members have an open schedule after lunchtime on Friday, Feb. 3.

Panel members requiring special arrangements to airport on Friday, February 3, should contact Dan Butrymowicz/Linda Luhn on Thursday, February 2.

OFFICE OF THE DIRECTOR

INSTITUTE FOR MATERIALS SCIENCE AND ENGINEERING

DIRECTOR

Lyle H. Schwartz
(301) 975-5658

DEPUTY DIRECTOR

Harry L. Rook
(301) 975-5658

SCIENTIFIC ASSISTANTS

Daniel B. Butrymowicz
(301) 975-5656
Samuel J. Schneider
(301) 975-5657

ADMINISTRATIVE OFFICERS

Elizabeth S. Sweitzer
(301) 975-5653
S. Michael Thomas
(301) 975-5654

PREFACE

The National Academy of Sciences-National Research Council (NAS-NRC) Board on Assessment of NIST Programs, and in particular the Panel for Materials Science and Engineering, performs an important role in the programs and success of the Institute for Materials Science and Engineering (IMSE). The Panel is one of our most effective means for assuring a continuous interaction between our staff and counterparts in the scientific and engineering communities of U.S. industry and academe. Each of the Panel members is selected by the National Research Council on the basis of expertise and extensive experience in the areas of research and technology conducted by the Institute. In addition to this Institute-wide Panel, we also have an Evaluation Panel for the Nondestructive Evaluation Program and for the Reactor Radiation Division.

The 1988 Annual Report was prepared for the NAS-NRC Board of Assessment of the Institute for Materials Science and Engineering. It consists of two parts: the first (this volume) contains background information on resources, activities, and representative highlights of the Institute. The second part details the technical activities of the Institute and is published separately as National Institute of Standards and Technology Internal Reports (NISTIR) for each Division/Office.

We look forward to your input and advice in both the evaluation and formulation process of our management decisions at all levels in the Institute. During this last year, I know that you have spent time in visiting our Institute and discussing programs, progress, and plans with our staff. I appreciate the time that you give and look forward to working with you in the future.

Lyle H. Schwartz

January 9, 1988

OVERVIEW

OVERVIEW

I. Introduction

The Institute for Materials Science and Engineering (IMSE) is responsible for providing the Nation with measurement methodology and technology, standards, concepts, reference materials, critically evaluated data, and other technical information on the fundamental aspects of processing, structure, properties, and performance of materials. These outputs are directed to the needs of U.S. industry, government agencies, academic institutions, and other scientific and technical organizations. The programs of IMSE support a wide base of generic technologies in materials, in order to provide their safe, efficient, and economical use in service. The research activities of the Institute address the science base underlying both advanced materials and conventional materials technologies, together with the associated measurement methodology.

The Institute consists of five technical Divisions: Ceramics, Fracture and Deformation (located at our Boulder, Colorado laboratories), Polymers, Metallurgy, and Reactor Radiation; and one independent Office: Nondestructive Evaluation, which sponsors cross-cutting research throughout NIST. Our budget in FY 1988 was approximately $47 million, including capital equipment acquisitions. IMSE has a NIST staff of 384, of which 89 percent are in scientific or technical support positions. Seventy-seven percent of our scientists and engineers have Ph.D. degrees. The average age of our full-time scientist and engineer staff is 46 years, compared to 47 years in 1987 and 48 years in 1986. This certainly reverses an aging trend we have been experiencing.

In addition to the NIST staff, we had 362 visiting scientists and engineers during 1988 involved in collaborative research or utilization of our special facilities (e.g., research reactor). These visitors represented U.S. industry, academe, other Federal agencies, and foreign institutions. Their stay at IMSE ranged from several weeks to the entire year and their salaries and associated costs were covered by the parent organization.

II. Major Organizational and Programmatic Events

1988 has been an exciting year for the staff of NBS, now The National Institute of Standards and Technology, and for members of the Institute for Material Science and Engineering. On their second attempt, Congress passed and the President signed the omnibus trade bill which, in part, created NIST and gave the organization a significantly expanded mission. Members of the Assessment Panel have been sent background information on the formal responsibilities of NIST and the implications of the legislation on the operations of NIST. One point must be emphasized to all friends and associates of NBS; the new NIST mission expands on the traditional NBS mission. NIST will remain the nation's lead laboratory for measurement research, standards, reference materials, critically evaluated data and other technical information. Programs and staff to carry out the new portions of the NIST mission will be critically dependant on the appropriation of new funds from congress. Other key issues, such as organizational changes and implementation of the technology transfer portion of

our new mission, associated with the transition to NIST will be discussed with the Panel at the February meeting.

In response to suggestions from panel members, the IMSE long range plan has been reorganized and updated. Major issues facing the materials science community have been addressed and the Institute's planned responses outlined. A copy of the plan was sent to panel members for their review and comments. As members of the panel will see, many of the issues are currently being addressed by the Institute in the form of increased research emphasis or programmatic initiatives to Congress in fiscal year 1990. The plan will be updated on an annual basis as a guide to Institute managers in research planning.

During the past year, the Institute has again been fortunate to be able to expand facilities and research activities with new initiative funding. The new building which will house the equipment and staff for the Cold Neutron Research Facility is now nearly complete. Dedication of the facility is scheduled for January 12, 1989 with occupancy to follow immediately. New scientific staff have been added to the program, particularly in the area of instrument design, construction and operation. The high performance composites program received first year funding and the polymer composites portion of that initiative has been started. The initiative funding in advanced ceramics is now at a stable level and the program is close to the anticipated level of new facilities and staffing. Partially as a result of the expanded advanced ceramics program, the Ceramics Division has undergone a reorganization to separate and highlight the areas of structural and functional ceramics. A new group to initiate a program in optical ceramics was formed and an intensive recruiting effort is currently underway to identify an established leader for the group. Research efforts in high temperature superconducting materials have increased substantially during the past year, crosscutting four divisions within IMSE and headed by Steve Freiman of the Ceramics Division. Programmatic objectives of these and other core programs of the Institute have been reviewed by the individual Divisional subpanels and for the first time, executive summaries of their findings are presented in this report as an overview for all panel members.

Specific highlights of this years programs follow in a summary format. These highlights are representative of Institute programs but are not meant to be all-inclusive. A more comprehensive review of the individual Division's programmatic outputs are given in the Divisions's Annual Reports.

Highlights

- The Cold Neutron Research Facility civil construction is proceeding well. This portion of the project is 95% complete, with beneficial occupancy scheduled for January, 1989. The number and cost of contract modifications (which arise from design changes and differing site conditions) is well below the contingency of 5%, and below the historic average for major construction.

- The D_2O ice cold source was successfully put into operation. Extensive startup tests were completed in the fall, and it has been in routine operation since December 1987. It has increased the neutron intensity available for the Small Angle Neutron Scattering and Time of Flight facilities by factors of 3 to 5.

- In the NIST/industrial consortium project to develop intelligent process control for inert gas high pressure metal atomization systems, progress was made toward the development of (a) a fundamental understanding of the liquid jet break-up leading to droplet formation, (b) real-time sensing techniques for in-situ measurements of droplet size distribution and velocity, and (c) a process model and expert system for the control of the atomization process. A number of flow measurement techniques were tested and evaluated for determining the salient features of the gas and liquid flows. These techniques included Schlieren and high speed photography, pressure and temperature surveys, and optical holography on a number of alloys and fluids. Pulsed holographic studies of the gas-only and gas-liquid flows were initiated for characterizing these flow fields and for photographing single liquid droplets. This work was initiated with water and metal alloys and will be continued with stainless steel (1700°C). A comparative evaluation of three point measurement techniques for particle sizing in the spray formation region downstream of the atomizer die and in the exhaust stream of its exit section, was performed for liquid sprays. Measurements were made during several stainless steel atomization runs with a laser diffraction technique to obtain a representative measurement of mean particle size and particle size distribution in the atomizer exit section. The design of an intelligent control system has continued. The execution control system on an Amiga computer was completed. The system program loads separate rule-based task modules, supports communication between them, and supports their operation in a multitasking environment. Software that permits interfacing particle size to permit the retrieval of results via a remote computer was developed. This project is a joint effort involving the Metallurgy Division, the Center for Manufacturing Engineering, the Center for Chemical Engineering, GE, Hoeganaes, and Crucible Materials Corporation.

- The NBS synchrotron radiation beamline capabilities for topographic imaging of the interior of crystalline materials have been used to observe, for the first time, defects which may be the "missing link" that materials scientists have been searching for to explain the performance limits of gallium arsenide single crystals.

- Atomic disorder on "plane" sites in 1, 2, 3 high T_c superconductors was found to be far more detrimental to superconductivity than disorder on "chain" sites, strongly suggesting the more critical role of the planes in the superconducting interaction. This neutron diffraction study of atomic substitutions for Cu also established the preferential occupancy of chain and plane sites according to the valency of the substituted atom.

- Using ultrasonic methods, we determined the complete 5-205-K elastic constants of several high-T_c metal-oxide superconductors: Y-Ba-Cu-O, Ho-Ba-Cu-O, Eu-Ba-Cu-O. Focusing on the yttrium oxide, we studied six specimens prepared at four laboratories. The bulk modulus, corrected to the void-free state, ranged over 54-101 GPa. Poisson's ratio, 0.21 ± 0.02, compares closely with that of $BaTiO_3$ (0.223) and $SrTiO_3$ (0.236), suggesting similar interatomic bonding. At T_c (near 91 K), within measurement error (0.1%), the elastic constants showed no discontinuity. Also, we discovered thermal hysteresis, suggesting a sluggish low-temperature phase transition.

- A constitutive equation has been developed which, for the first time, describes the nonlinear mechanical response in a stress relaxation experiment for a semi-crystalline polymer. The predictions of the new description are in good agreement with data from a series of single and multistep stress-relaxation experiments done in uniaxial extension on an ethylene-hexene copolymer.

- For the first time, the deformation topologies of stress waves propagating in anisotropic materials have been calculated using finite element analysis (FEA). To confirm the calculations, acoustical arrays of piezoelectric polymer elements were developed to measure elastic wave propagation in graphite-epoxy composites. The measurements agreed well with the values calculated by FEA using known elastic properties of graphite and epoxy.

- A model and accompanying database permitting detailed composition calculations of multicomponent-multiphase oxide systems representative of typical steel slags and the refractories used in steel processing has been developed. The model data currently contains over 125 species and has been successful in predicting activities in up to eight component systems. Several industries are beginning to substitute this model for the overly simplistic chemical models currently used in transport-type processing models.

- The formability of sheet metal, which in large part depends on grain texture or grain orientation, is a significant process variable in the manufacture of such diverse items as beverage cans, appliances, and automotive panels. In order to improve process control, a noncontacting ultrasonic method was developed last year for on-line monitoring of texture in aluminum sheet. This year's research in the Fracture and Deformation Division, in collaboration with the Advanced Steel Processing and Products Research Center, demonstrated that the technique is also applicable to thin ferritic steel sheet.

- The determination of surface roughness during machining of bulk metal parts is desirable for both quality control of the finished product and control of the cutting or grinding process. In a project in the Center for Manufacturing Engineering (CME), an ultrasonic NDE sensor was developed two years ago for on-line monitoring of surface finish and last year's research successfully demonstrated that the same ultrasonic sensor could be utilized to detect on-line worn or damaged cutting tools. This year's research shows that a finely focused ultrasonic beam can be used to map the topography of a surface in a fashion analogous to the contacting stylus profilometry technique.

- An eddy current method for sensing the internal temperature of aluminum during extrusion processing has been developed. a simple encircling coil technique has been successfully evaluated in plant trials on simple shapes of circular or square cross-section (solid and hollow) and a two coil transmission technique has been tested in the laboratory for more complex geometries.

- Inexpensive techniques have been developed to determine the creep and creep rupture properties of structural ceramics to temperatures as high as 1500°C. The use of laser imaging to measure creep displacements to accuracies of ± 1 nm has allowed evaluation of silicon carbide and silicon nitride composites with potential for use in heat engine and heat exchanger applications.

- An optical diffraction technique has been developed to measure full-field strains in tensile panels. It is being used to observe the accumulation of damage in composite materials prior to failure. The diffraction patterns of deformed and undeformed grids are compared to obtained strains and rotations.

- High speed holograms (exposure times of 20 ns) and high speed motion pictures (10,000 frames/s) were used to investigate the operative disruption mechanisms during inert gas atomization of Sn-Sb and stainless steel alloys. This is the first application of holography techniques to metal atomization.

- Recent research to exploit neutron reflection and grazing angle diffraction as powerful probes of surface and interfacial structures has produced very promising results. As an example, we have carried out (with IBM) a dramatically successful first study of lamellar formation and surface ordering in diblock copolymer films and have demonstrated the ability to measure reflectivities as low as 10^{-6}.

- A laboratory has been constructed to study the forces present between solid surfaces in close proximity (10-100 nm). This laboratory, one of only a few in this country, will provide data required for a fundamental understanding of phenomena occurring in fracture and lubrication of ceramic materials.

- In the design of polymers for nonlinear optics, diacetylene monomers which undergo multiple transitions to liquid crystalline states prior to melting have been synthesized. Thermally activated polymerization has been shown to occur not only in the solid state but also within the liquid crystalline states - with an activation energy of only 40% of that in the solid state. Furthermore, the resulting orange-colored polymer retains much of the long-range order present in the liquid-crystal precursor

- A new "Standard Test Method for Minimum Detectable Temperature Difference for Thermal Imaging Systems," which was developed in the NDE Program, is proceeding through the ASTM balloting process. This document represents the second of three test methods that will define the critical performance parameters of thermographic NDE instruments. (The first standard, on minimum <u>resolvable</u> temperature difference, was adopted by ASTM last year.)

- As a result of a United States-Japan program, standards for tensile and fracture-toughness testing at 4 K have been submitted to ASTM. Cooperative research included round-robin tensile and fracture tests of an Fe-24Cr-15Ni alloy and investigations of the effects of specimen size, side grooves, test speed, and fatigue cracking on fracture toughness test results.

- The Division, in cooperation with the American Ceramic Society, has completed data entry for Volume 7 of the widely used "Phase Diagrams for Ceramists". This volume will contain approximately 4,000 critically evaluated phase diagrams and a 2,000 word citation bibliography emphasizing hydrated and high pressure systems.

- Certification measurements have been completed for a poly(methyl methacrylate) Standard Reference Material, SRM 1487. Produced with partial support from the Navy, this SRM will be used for quality control of antifouling paints and as a calibrating material for the analysis of acrylic polymers. Material has also been obtained and work started on the first of two polyurethane Standard Reference Materials, produced with partial support from the Food and Drug Administration, which will help meet a growing need for better methods of characterizing polyurethane used in medical devices.

RESPONSE TO 1987
PANEL CONCERNS

IMSE RESPONSES TO 1987 PANEL CONCERNS

This section reviews explicit concerns raised by the IMSE Panel on Assessment in their 1987 Report. A more complete discussion of these concerns, as well as those raised by the Division's subpanels, will be held during the 1988-1989 meeting.

CONCERN: "The Panel is concerned about the gradual shift away from the traditional role of NBS and IMSE as the developer and keeper of standards. ....The level of IMSE standards effort, such as data compilation may be inadequate to meet the needs of U.S. industry, academia, and government."

RESPONSE: The management of NIST and of IMSE is aware of the deep concern among our external constituency that the NBS role as the Nation's lead laboratory for measurement research, standards, data and reference materials may diminish as the additional technology transfer responsibilities of NIST are implemented. We in IMSE are committed to maintaining the full level and quality of measurement research, data and standards programs that our industry and science constituency have come to rely on.

CONCERN: "There appears to be a lack of support for the data centers. ....The Panel recommends that NBS take an aggressive role in collating, comparing and evaluating these data...."

RESPONSE: As pointed out in the Panel's report, IMSE currently has joint data programs with ASM, ACerS, and NACE. These and other data programs sponsored by the Office of Standard Reference Data, IMSE and other federal agencies represent a significant technical effort on the part of IMSE scientists. However, we recognize that there are other high priority data programs, such as those mentioned in fracture toughness, tensile testing and creep that, with additional resources, could have a valuable impact in the materials community. The real issue is the availability of additional resources and that will be a continuing challenge for the IMSE and NIST management.

CONCERN: "The panel is also concerned that IMSE essentially not involved in research on semiconductor materials such as silicon and the III-V compounds."

RESPONSE: As seen in both our long range plan, our new program in high Tc superconducting materials and in the reorganization of the Ceramics Division, IMSE management has made the decision to increase our programmatic emphasis in functional materials. At the present time however emphasis is not planned on semiconductor materials since there is already a substantial program in existence in the Center for Electronics and Electrical

Engineering. We plan instead to focus our attention on photonic materials and superconducting materials.

CONCERN: "The Panel notes further that fracture, or separational mechanics is an interdisciplinary phenomena ....conducted in at least three IMSE Divisions. An annual summary report, indicative of the total NBS program appears appropriate.

RESPONSE: Management is not entirely clear on the intent of this suggestion. A report of this nature on cross cutting activities within the Institute could be just a document for panel information or it could be prepared for a larger external audience. The choice of areas, i.e. research on high T_c superconducting materials vs. a report on fracture would be largely determined by the intended audience. We will discuss this suggestion in more detail with the Panel during the meeting.

NAS-NRC PANEL ON ASSESSMENT 1988 SUMMARY REVIEW OF DIVISION PROGRAMS

AN EVALUATIVE REPORT ON THE OFFICE OF NONDESTRUCTIVE EVALUATION

Panel Members

Gordon S. Kino, Stanford University, Chairman
George Alers, Magnasonics
Spencer H. Bush, Review and Synthesis Associates
Joseph A. Giordmaine, NEC Research Institute
Edmond G. Henneke, II, Virginia Polytechnic Institute and State University
Robert W. McClung, Consultant
Charles M. Vest, Michigan University

This report submitted for the Panel by the Chairman, Gordon S. Kino, is an annual assessment of the activities of the Office of Nondestructive Evaluation, based on a meeting of the Panel on November 14-15, 1988.

SUMMARY

The Panel continues to be pleased with the progress in the nondestructive evaluation work at NIST. This Office has pioneered the application of NDE to material processing and has bought to the attention of the industrial community the possibility of using NDE techniques for automated manufacturing. The ONDE has shown real leadership in holding workshops on, and then proposing and carrying through new initiatives in, automated processing.

The present program on intelligent processing for powdered metals is first rate and appears to be making good progress. Drs. Yolken and Mordfin are to be complimented on having the insight to propose and carry through this initiative. However, it is vital for the internal leadership to be strong enough to ensure that the basic aims of this manufacturing program are kept well in mind by all the participants, and that they all work well together. The program is underfinanced, and needs an increase in funding of $200,000-$300,000/year to have any hope of meeting its goals within the time proposed. Even then, the time scale proposed is an optimistic one.

The Panel is concerned to see that the techniques for technology transfer to industry are optimized. It has been our concern that projects are too often terminated at the stage when a scientific researcher is satisfied with the results, but before simple demonstrations of their worth is made to less sophisticated and involved industrial people. To do this, we have suggested two relatively simple demonstration projects illustrating intelligent processing:

(1) Automatic control of the extrusion machine by the aluminum temperature measurement sensor; and

(2) Automatic control of a lathe or mill by the surface roughness measurement system. This will require a more extensive evaluation of the significance on tool wear and cutting rates of the measurements.

The projects suggested are much simpler than the major project on automated processing of powders which must, by its nature, take some time to demonstrate its worth. It is for this reason that we would like to see a number of initial demonstrations of this type.

For the same reasons, the Panel encourages ONDE to publish descriptions of its work in general magazines of interest to industry, as well as publishing in the standard scientific journals, as they presently do.

ONDE, like much of the rest of NIST, has been working with a constant dollar budget for several years. In the opinion of the Panel, it is most desirable to increase the financing of this Office because of the great importance of their current work to improved manufacturing efficiency in this country.

AN EVALUATIVE REPORT ON THE CERAMICS DIVISION

Sub-Panel Members

Maxine Savitz, Garrett Processing Company
Robert Laudise, ATT&T
Joseph Panzarino, Norton Company

This report is based on a meeting of the Ceramics Sub-Panel on December 13-15, 1988.

SUMMARY

<u>Structural Ceramics</u>

1. Ceramic Powder Synthesis Characterization and Processing - A. Dragoo
2. Mechanical Properties - D. Cranmer
3. Tribology - S. Jahanmir

<u>Functional Ceramics</u>

4. Electronic Ceramics - S. Freiman
5. Optical Materials - A. Feldman
6. Synchrotron Radiation Analysis - M. Kuriyama

The Committee agrees that this reorganization is timely, appropriate and will constructively help to focus the Division.

However, we have some concerns about the new organization. The data base work appears to have lost some emphasis. Although not warranting organizational breakout because of its present small size, we would recommend treating "Data Base" work as a separate activity wherever appropriate. This would help to focus and nurture this vital activity. We will follow this plan in the next section of our report which is otherwise organized according to the new divisional alignment.

Altogether, we found the morale of the Division very good and complement the Division leadership for its adroit management through a time of change. However, we would recommend against any major reorganization in the next few years in the absence of compelling reasons. Furthermore, we strongly recommend that while the new NIST - "technology transfer" emphasis may be much needed nationally, these directions should only be undertaken if they do not in any way reduce manpower of financial support for the traditional role which NIST does so well and for which they are a unique national resource: STANDARDS WORK.

Conclusions and Recommendations for the Ceramics Division of NIST

The following are our principle conclusions and recommendations:

- The additional tasks of funding and managing the new NIST task must be funded separately or serious questions about NIST-wide activities must be asked as to what program should be dropped to take on these new responsibilities. It is not only money; it is also the mix of people, both talent and desires.

- The Division has been well and artfully managed through changeful times and the most recent organization was useful and effective but we recommend that future organizational changes should take place only in the presence of a compelling external need.

- We were surprised to discover that no group has a responsibility for core competence in solid state physics in NIST. The effectiveness of programs directed towards electronics, the electronic industry and electronic materials, we believe, would be inestimably improved with inputs which such a group could give.

- The phase equilibria work of the Center is world class and if more fully manned can have a greater impact. A manpower increase is indicated, we believe. Optical materials is very much in need of external customers in order to insure its relevance and impact. The possibilities if II-VI optical/electronic materials and other semiconductors with, for example, DOD might be explored.

- Nondestructive testing activities have always been and continue, we believe, to be among the crown jewels of NIST. Excellent work on diamond film characterization and synchrotron evaluation of ceramics and semiconductors gives evidence of continued health in that direction and a demonstration, we believe, the continuing vital impact such work can have. We particularly applaud activities of this sort.

AN EVALUATIVE REPORT ON THE FRACTURE AND DEFORMATION DIVISION

Sub-Panel Members

George Irwin, University of Maryland
John Mihelich, Comalco/Australia

This report is based on a meeting of the Fracture and Deformation Sub-Panel on October 20-21, 1988

SUMMARY

The Fracture and Deformation Division is organized along functional lines into five groups termed Fracture, NDE and Composites, Welding and Processing, Cryogenic Materials, and Physical Properties. Progress within these groups was reviewed during a two-day visit at their Boulder, Colorado location, October 20-21, 1988. Substantial progress was evident and is well presented in Division reports. The Division program is consistent with current IMSE-NIST goals and seems to require no major changes.

The Division is giving special attention to research which can improve structural safety, enhance industrial productivity, and/or assist use of advanced materials. Only a few illustrative examples will receive comment here.

Research on thermomechanical processing of metals, using a deformation processing simulator, is a relatively new line of research for the Division, and one which shows good progress. A simulation of controlled rolling (CR) followed by direct quench (DQ), using a Navy grade HSLA 80 steel, demonstrated that improved strength and toughness could be achieved using a CR-DQ fabrication method. A prototype ultrasonic system was constructed for measurement of anisotropy (texture) in steel sheets and a correlation between formability and the ultrasonic measurements was found.

The composite materials currently being studied have an epoxy matrix and graphite fibers. The goal is to assess damage using both NDE measurements and sound analytical modeling. The tendency of damage in composites of this kind to be scattered rather than localized suggests a need for special attention to damping. The complexities are challenging and continued work on this topic will be rewarding. Other physical property studies which have received recent attention include austenitic steels and high temperature superconductors.

The Division has been assisting the development of ASTM test methods for fracture testing of weldments. In addition, the Cryogenics group is leading the establishment of ASTM methods for fracture at cryogenic temperatures. Activities given to testing standards are of special value both for the usefulness of the product and for the contact with industry which accompanies these efforts.

The recently completed addition for large testing machines is now in use and provides a helpful increase of testing capability. Improvements in office space will be provided soon by adjustments of room usage. The mix of fundamental and applied research topics in the program of this Division moves ahead with interest and mutual aid in a manner consistent with competent leadership, high quality staff, and a friendly atmosphere. Possibly, the compact housing remote from Gaithersburg has some value in terms of esprit de corps.

AN EVALUATIVE REPORT ON THE POLYMERS DIVISION

Sub-Panel Members

Byron Pipes, University of Delaware
Dick Stein, University of Massachusetts
Peter Juliano, General Electric

The report of the Polymers Division Sub-Panel was not available at the time of reproduction of this report.

AN EVALUATIVE REPORT ON THE METALLURGY DIVISION

Sub-Panel Members

Bernie Kear, Rutgers University
Bert Westwood, Martin Marietta
Ian Hughes, Inland Steel (Not Able to Attend)

This report is based on a meeting of the Metallurgy Sub-Panel on November 9-11, 1988.

SUMMARY

The emphasis in the Metallurgy Division on developing new methods of measurement, the creation of reliable standards, and the compilation of data bases on materials properties seems entirely appropriate for the new Charter of NIST.

Clearly, developments in these areas will have a major impact in future materials technologies, provide a resource base for materials design, and facilitate the development of fully integrated manufacturing technologies for the future.

Specific Comments

Some observations on the programs visited are as follows:

- The metals processing program is becoming one of the most productive in the Division and is benefiting from the long-term commitment to the goals of developing the science-base for the powder metallurgy processing technologies of the future. The fact that three major industrial partners have made a multi-year commitment to this program is testimony to the value placed on the designated program thrusts.

  The incorporation of innovative measurement systems within the particle atomizer to establish the mechanism and particle size distribution under different processing conditions is the key to optimal processing, product quality, and reproducibility. We endorse the use of laser diffraction, high-speed photography, and particularly holography as a means to achieve in-situ particle characterization. More creative probes of this type will be needed for intelligent processing of the next generation of high-performance materials.

  Extension of this powder metallurgy program into near-net shape fabrication (e.g., H.I.P.) is worthwhile. With DARPA support and input from industrial partners, rapid progress should be made in this consolidation program.

- The growing importance of titanium aluminides and Al/Li offerings in the aerospace and defense industries makes this an attractive area for focused research. With a little bit of publicity, it should not be hard to create a network of industrial partners who are already working on the technology and have an urgent need for supportive basic research. Understanding the microstructures at the nano-scale is an area of opportunity that nicely complements many science interests of the Division staff.

- Concerning the product design life cycle, it is imperative to ensure that information on the corrosion susceptibility is available. In the past, this has been neglected and we have suffered the consequences in numerous application areas. It will be important with the emerging materials (i.e., Ni_3Al, TiAl, etc.) for the Institute to seize the initiative in promoting basic corrosion studies at the same time as the mechanical property data base is being developed. A good example is the unexpected finding of H_2 embrittlement and consequent intergranular failure of B-doped Ni_3Al in aqueous environments of varying pH.

  We were extremely impressed by the progress made in the NACE-NIST Corrosion Data Center. We think it is only a matter of time before the Center has a series of best sellers on its hands. In fact, we see a lack of appreciation of marketing and salesmanship in this area which, if addressed properly, could be a source of continuing revenue for years. For example, if the data base was properly packaged for specific industrial segments (i.e., energy, transportation, paper and pulp, chemicals, food packaging, etc.), it would have more widespread and focused utility.

- Concerning electrodeposition, there is little doubt in our minds that this is the best research program today in this field in the Nation. With the limited resources available, they continue to make progress in the synthesis of novel materials, including intermetallic compounds, dispersion-strengthened materials, and composition-modulated structures. The ability to control the wavelength of the modulation down to one nanometer is an extraordinary achievement, and this is a testimony to the degree of understanding that this group has brought to electrodeposition. In addition to applications of these materials as wear-resistant coatings and scraping blades, it seems that there may be numerous additional applications in electronic packaging, and as super-stiff coatings for fibers. Furthermore, the ability to achieve high deposition rate coatings could make a significant impact in the processing industry.

- In addition to the ongoing interactions with the steel industry, the work in high-temperature materials chemistry also offers the possibility of interaction with the high-temperature materials community, such as the industrial consortium working on hypersonic flight (i.e., NASP). The accomplishments made in laser-induced vaporization mass spectrometry offers opportunities for non-destructive measurement of high-temperature materials for improved process control.

- The research in magnetic materials continues to set new standards in the field, which is to the credit of the group. We were particularly impressed with the work on high T_c superconductors and the probing of the site occupancy of Fe using Mossbauer spectroscopy. The addition of new measurement equipment (i.e., SQUID magnetometer) will add considerably to the capabilities of this group and their ability to compete in this fast-moving field. We are still skeptical, however, that the Barkhausen magnetic noise technique will become a viable NDE technique. A particular problem appears to be making the procedure defect specific in a reproducible manner.

- Significant achievements have been made in the Advanced Sensing Program, both in fundamental understanding of measurement principles and in collaboration with industry for specific applications. The developments of eddy current temperature sensor of extruded bars for the Aluminum Association and ultrasonic temperature measurement of steel for the AISI appear to be quite successful. Furthermore, the activities on density measurement during HIP processing, on a methodology for mapping of liquid-solid interface in metal, on microstructure sensing during Plasma Deposition, and on modeling and control of intelligent processing systems will undoubtedly be impactive to the industry.

  There are ample opportunities for further expansion of this much-needed advanced sensor research. We feel the Institute has a large number of scientists with expertise in diversified disciplines required for innovative sensor development. These are highly valuable national resources that can gain the U.S. industry the leadership over our overseas counterparts. Therefore, the Metallurgy Division should consider establishing an initiative on measurement science with high priority and provide the focus for advanced sensor development for the metal industry.

Lastly, we were distinctly impressed by the Industrial Affiliates Program and the continuing interactions between researchers from the Institute and the Industrial Research Laboratories. Clearly, the Institute has identified a niche for itself in the area of in-situ diagnostics of the metal atomization process which, in due course, should provide the basis for a fully integrated powder metallurgy technology with feedback control of all critical processing parameters. It is our opinion that patentable ideas will naturally emerge from this program, especially in the instrumentation category. Such inventions are ideal for small business activities. This raises the question of the nature of the reward system to the Institute inventors. We do not know what the patent policy is at the Institute, but we feel strongly that a system of monetary incentives should be established to encourage researchers to take an interest in technology transfer and innovation. As an advisory group, we would like to see this item on the agenda at the next meeting with an in-depth report from Management.

AN EVALUATIVE REPORT ON THE REACTOR RADIATION DIVISION

Panel Members

John McTague, Ford Motor Company
Michael Fisher, University of Maryland
Michael Wilkinson, Oak Ridge
Julia Weertman, Northwestern University
Max Yeater, Renssalaer

This report is submitted for the Panel by the Chairman, John MacTague, is an annual assessment of the activities of the Reactor Radiation Division, based on a meeting of the Panel on December 6-7, 1988.

SUMMARY

During 1988 there was substantial progress within the Reactor Radiation Division in support of its expanding role as a national resource. This is particularly timely in view of difficulties being experienced at some other U.S. neutron facilities.

The cold neutron guide hall is nearing completion, on time and on budget. The dedication ceremony for the Cold Neutron Research Facility is scheduled for January 12, 1989. Supplementation of the permanent staff has continued, with hiring of several instrument responsibles and technicians for the new spectrometers. This substantial progress has benefited from excellent, sustained encouragement and support from all levels of NIST administration. The panel commends their farsightedness in a period of budgetary stringency.

The scientific and technical program at RRD continues to be broad in scope and in collaborations with industry, academe., and national laboratories. Particularly promising is the new effort in neutron reflectrometry to study the nature of polymer interfaces.

In 1988, the reactor experienced extended periods of down time and operation at reduced power, mainly because of installation of the cold neutron capability. In general, over the years, the reactor has operated reliably and with high degree of up time. Continued high levels of attention to preventative maintenance are clearly a wise investment.

The historical and continuing synergy between RRD and other divisions and institutes at NIST has been beneficial. The Panel notes that interaction between neutron experimentalists and condensed matter theorists is particularly fruitful in general, and encourages IMSE and other institutes of NIST to examine the possibility of further investment in condensed matter theory to a level more commensurate with the past.

As in last year's report, the Panel continues to urge RRD to be more aggressive in publicizing NBSR's new national user role. A full time professional for this function is clearly warranted immediately, rather than waiting for full scale operation of the Cold Neutron Research Facility. Also, more formalized methods for assuring broad input of the external scientific

community in developing user policy and general scientific directive of the facility should be implemented as soon as possible.

1989 is a milestone year for RRD in several ways. The dedication of the Cold Neutron Research Facility signals a strong, productive future for RRD. This potential, however, does not stand isolated. The many years of dedicated leadership of Robert S. Carter, from the earliest days of the NBS Reactor, have played a critical role in the creation, maintenance, and enhancement of this facility and NIST is greatly in his debt at this time of his retirement. Fortunately, he will continue to give valuable advice to RRD, and fortunately, he is being succeeded by a world-class scientist and administrator, J.M. Rowe.

PERSONNEL

SUMMARY OF STAFF

Full Time Permanent		1986	1987	1988
Physicist		67	65	66
Chemist		49	45	46
Metallurgist/Matls. Scientist		44	39	47
Engineer		31	32	42
Other		3	3	9
	Subtotal	194	184	210
Technical Support		33	35	32
Reactor Operators		15	16	15
Management Support		5	7	12
Secretarial		27	31	28
	Subtotal	80	89	87
	TOTAL FTP	**274**	**273**	**297**
Other				
NRC-NAS Postdoctorals		16	11	15
Part-Time and Temporary		42	46	29
Academic (Student and Faculty)		78	59	51
	Subtotal	136	116	95
	TOTAL STAFF	**410**	**389**	**392**

FY 1988 POSTDOCTORAL PROGRAM

Unit	Name	Degree	School	Position Title	Advisor
Ceramics	Cline, James	Ceramics	Alfred U.	Cer Engr	Hubbard
	Coyle, Thomas	Matls Sci	MIT	Cer Engr	Wiederhorn
Fracture & Deformation	Fitting, Dale	Engr Sci	U. of TN	Matls Res Engr	Kriz
	Heylinger, Paul	Engr Sci	VPI	Matls Res Engr	McHenry
Polymers	Clark, John	Chem Engr	U. of MN	Chem Engr	Han
	Coyne, Laurence	Pol Sci/Eng	U. of MA	Matls Res Engr	Wu
	Douglas, Jack	Chemistry	U. of Chic	Res Chemist	Han
	Duran, Randolph	Poly Sci	U. L. Past	Matls Res Engr	McKenna
	Jackson, C.	Poly Sci	U. of CT	Gen Phy Scient	McKenna
	Krueger, Susan	Physics	U. of MD	Res Physicist	Olson
	Lee, Andre	Matls Sci	U. of IL	Matls Scientist	Hunston
	Nakatani, Alan	Matls Sci	U. of CT	Matls Scientist	Han
Metallurgy	Davidson, Paula	Ear/Sp Sci	SUNY	Res Chemist	Hastie
	Janowski, G.		MI Tech U.	Metallurgist	Fields
	Johnson, Ward	Physics	U. of IL	Physicist	Wadley

FY 1988 ACADEMIC PROGRAM

Appointments				
	Undergraduate Students	Graduate Students	Faculty	Totals
NDE	---	---	---	---
Ceramics	11	4	---	15
Fract & Defor	1	---	---	1
Polymers	12	---	4	16
Metallurgy	16	---	---	16
Reactor Radiation	---	---	2	2
Totals	40	4	6	48

VISITING SCIENTIST PROGRAM

Guest Researchers	FY 1986	FY 1987	FY 1988
Domestic			
Federal	30	34	52
Academic	68	66	104
Industry	42	42	28
Self-Employed	17	17	23
Subtotal	157	159	207
Foreign	122	129	74
Subtotal	279	288	281
Research Associates			
Federal	4	4	5
Academic	1	1	17
Industry	89	79	68
Subtotal	94	84	80
Intergovernmental Personnel Act (Academic)	4	2	1
TOTAL	377	374	362

HONORS AND AWARDS

DEPARTMENT OF COMMERCE AWARDS

1986-1988

GOLD MEDAL (Exceptional Service)

Charles C. Han	for his innovative use of small angle neutron scattering to address significant problems in polymer science. (1986)
Arnold H. Kahn	for theoretical studies of electromagnetic field interactions with metals and alloys. (1988)
James J. Rhyne	for international leadership in critical research on advanced magnetic materials for high-technology products and devices. (1987)
Robert S. Roth	for meritorious authorship in the field of ceramic phase equilibria, including editorship of the internationally renown Phase Diagrams for Ceramists volumes. (1986)
Robb M. Thomson	for outstanding contributions as a world leader in the field of fracture in materials. (1987)

SILVER MEDAL (Meritorious Service)

Brian R. Lawn	for innovative research on the fracture of brittle materials and for pioneering work in the field of fracture mechanics. (1986)
Harry I. McHenry	for leading research and supervision in elastic-plastic fracture mechanics, leading to new fitness-for-service criteria. (1986)
Joseph J. Ritter	for pioneering research which led to novel routes for producing ceramic powders. (1988)
Antonio Santoro	for developing highly important theoretical and experimental methods for measurement of the structures of materials. (1988)
Haydn N.G. Wadley	for contributions to a program aimed at the development of sensors and their integration into automated control systems for materials processing. (1988)
Wen-li Wu	for the development of a unique and powerful technique for analyzing the molecular structure of polymers used in composites. (1987)

BRONZE MEDAL (Superior Service)

John E. Blendell	for outstanding contributions and leadership in the development of processing high-temperature ceramic superconductors. (1988)
Yi-Wen Cheng	for development of a thermomechanical processing simulator. (1988)

Alfred V. Clark	for outstanding contributions to the nondestructive evaluation of materials and components. (1987)
Edmund A. Di Marzio	for outstanding theoretical contributions to the understanding of glass transition, polymer crystallization, non-exponential relaxation in amorphous materials, polymer interfaces, and structure induced phase transition. (1988)
James G. Early	for developing guidelines to compare domestic and foreign specifications for alloys used in the construction of ships. (1986)
Camden R. Hubbard	for extensive accomplishment in improving materials characterization by x-ray powder diffraction. (1986)
Paul A. Kopetka	for engineering design, supervision of fabrication, and the final testing and installation of the NIST cold neutron source. (1988)
Chia-Soon Ku	for development of oxidation measurements and standards for the Nation's petroleum and transportation industries. (1987)
David S. Lashmore	for contributions to the development of electrodeposited composition modulated alloys. (1986)
J. David McColskey	for developing experimental methods, instrumentation, and fixtures which put NBS at the forefront of fracture mechanics research. (1986)
Gregory J. Olson	for important contributions to inorganic materials biotechnology and bioengineering. (1986)
Stephen D. Ridder	for outstanding contributions to the study of atomization processes in metals. (1988)

Gery R. Stafford	for contributions to the understanding of the electrochemical deposition of aluminum-titanium intermetallic compounds. (1988)
John A. Tesk	for his exceptional leadership of a highly diverse program that has improved the performance of dental materials. (1986)
S. Michael Thomas	for consistently outstanding contributions to the administrative and fiscal operation of the Polymers Division. (1986)

FELLOW AND SENIOR FELLOW (Established by NBS Director to provide recognition to most outstanding scientists)

John Cahn	Elected to Senior Fellow
Brian R. Lawn	Elected to Fellow
John J. Rush	Elected to Fellow
Robb M. Thomson	Elected to Fellow
Sheldon M. Wiederhorn	Elected to Senior Fellow

NIST AWARDS

1986-1988

PRESIDENTIAL RANK OF MERITORIOUS EXECUTIVE

John J. Rush (1986)

EDWARD BENNETT ROSA (Outstanding achievements in the development of significant standards of practice in the measurement field)

Samuel J. Schneider	for outstanding contributions and leadership activities in developing and promoting standards in materials science and engineering. (1988)

STRATTON (Outstanding scientific or engineering achievements)

John Cahn	for outstanding achievements in the field of physical metallurgy. (1986)

EQUAL EMPLOYMENT OPPORTUNITY (For exceptionally significant accomplishments and contributions to EEO and Affirmative Action goals)

Jonice S. Harris	for outstanding contributions to the NBS and IMSE EEO/Affirmative Action Programs. (1986)

CRITTENDEN (Superior accomplishments by support staff)

David R. Kelly	for outstanding and unique electroplating services to the NBS staff. (1986)

SAFETY (Significant contributions to Safety Program)

Ralph F. Krause	for outstanding tenure as Ceramics Division Safety Officer, enhancing safety awareness and maintaining an excellent safety record. (1987)
John E. McKinney	for leadership of the safety program in the Polymers Division.

EXTERNAL RECOGNITION

1986-1988

Ugo Bertocci	14th William Blum Award, National Capital Section of the Electrochemical Society for his work on elastrochemical noise to study the stability of passive films (1986).
Robert S. Carter	Elected Fellow of the American Nuclear Society (1986).
	Steering Committee for an Advanced Steady-State Neutron Source in the U.S. (1986).
J. Beverley Clark	Elected Fellow of American Society for Metals (1986).
Edwin Fuller	Ross Coffin Purdy Award of the American Ceramic Society for his valuable contribution to the ceramic technical literature (1987).
Charles Guttman	Elected Fellow of the American Physical Society (1987).
Charles Interrante	George Kimball Burgess Memorial Award by the American Society for Metals for significant contributions to the field of metallurgy (1987).
David S. Lashmore	Elected Vice President of Electrodeposition Division of the Electrochemical Society (1986).
David S. Lashmore	Elected President of the Electrodeposition Division of the Electrochemical Society (1988).
Brian Lawn	Elected Fellow of American Ceramic Society (1986).
M. Linzer, H. Wadley, D. Supperman (Argonne), L. Spivak (Magnaflux)	I-R 100 Award for development of an Ultrasound Pipe Porosity Sensor given by Research and Development magazine (1987).
John R. Manning	Elected Fellow of American Society for Metals (1986).
Chris McCowan	Honorable Mention Award at the International Metallographic Contest, for his contribution, "Microstructural Characterization of Y-Ba-Cu-O Superconductors" (1988).
Gregory B. McKenna	Elected Fellow of the American Physical Society (1988).

Elio Passaglia	ASTM Award of Merit for outstanding contributions to the advancement of voluntary standardization (1987).
Marshall Peterson	The Mayo D. Hersey Award of the ASME, in recognition of his many contributions which led to an improved understanding of friction, wear, and lubrication of materials. (1988).
Lyle H. Schwartz	Elected Fellow of ASM International (1987).
Dan Shechtman	International Prize for New Materials by the American Physical Society for his experimental discovery of phases of matter that exhibit icosohedral symmetry (1987).
Dominique Shepherd	First Place Award at the International Metallographic Contest, for her poster, "Advantages of Light Microscopy for Measuring Twin Dimensions in High-Temperature Superconductors" (1988).
Tom Siewert	Selected as the annual recipient of the American Welding Society Honorary Membership Award (1988).
T. Siewert P. Purtscher R. Trevisan	International Metallographic Society for their development of a metallographic technique that analyzes welds and welding processes by completely exposing the weld fusion line (1986).
Sheldon Wiederhorn	Dow Distinguished Lecturer in Materials Science and Engineering, Northwestern University, Department of Materials Science and Engineering, in recognition of his outstanding contributions to materials science and engineering (1988).

IMSE LONG RANGE PLAN

EXECUTIVE SUMMARY

LONG RANGE PLAN

THE INSTITUTE FOR MATERIALS SCIENCE AND ENGINEERING

EXECUTIVE SUMMARY

Mission, Policy and National Trends

The Institute for Material Science and Engineering (IMSE) plans it's programs in response to the basic NBS Organic Act, Administrative and Congressional policies and with an understanding and close tie to national trends in industrial and manufacturing technologies. The Organic Act provides a rationale for research in measurements, data, standards and other technical information fundamental to the synthesis, processing, structure, properties and performance of materials. A major emphasis in the Institute's planning process has been to utilize close cooperation with industry to obtain input on national trends in materials research, measurement methods, data, and standards necessary to support manufacturing technologies. Historically, the Institute has organized and planned programs along discipline lines to respond to the NBS mission. This structure has enabled IMSE to develop internationally recognized programs in materials characterization, structure/property/performance relationships, materials data compilations, and standards for many economically important materials.

During the past decade, a concurrent change in Administrative policy and Congressional focus on enhanced industrial competitiveness in the international arena has led NBS to expand on its traditional role. New programs have been proposed to Congress which will aid U. S. industries in developing new products or in improving current product quality, performance and cost, thus improving competitiveness within the international community. The NBS long range plan, developed in 1985, addresses these additions to NBS' mission and uses an economic analysis, trends and impact review model to aid NBS in planning for future programs. IMSE utilizes NBS planning information and it's unique interactive position with U.S. industrial users of materials to identify trends and needs in materials science research and to develop future programs. With this planning information, the Institute identifies gaps in current materials science research, data, and standards and develops plans whereby the Institute can make the broadest impact on major industrial sectors of the U.S. economy.

Macro Trends in Materials Science

Two major trends in the materials science community are fundamentally changing the process of transferring research output in materials science to industrially utilized materials. The first trend is the shift in balance from primary manufacturing materials to new, high technology, high value added materials which are developed specifically to satisfy one or more unique functional or structural needs. Many of these materials are initially driven by defense or aerospace requirements and enter the general industrial marketplace when the manufacturing process technology and cost allow them to

compete with more conventional materials. Recent economic planning estimates indicate that industrial growth in these high technology materials areas will constitute the major economic expansion in materials use as we go into the next century. Industries which concentrate on manufacturing with conventional metals, polymers and ceramics will at best be adiabatic and will be at a severe competitive disadvantage within ten years. Industries which can rapidly and successfully adopt new materials into their manufacturing processes to improve performance, reliability, or cost will be in a position to develop a worldwide edge in competitiveness. To achieve rapid utilization of new materials, industry must replace the sequential development process now in use with a more parallel process of material synthesis, characterization, performance evaluation, and introduction into the manufacturing process. A major factor in the IMSE plan is the Institute's traditional role in characterizing and developing test methods, data, and standards for evaluating materials being developed by the U.S. materials science research community and aiding industry in using that information to improve materials performance in U.S. manufactured products.

The second trend in materials science, recognizing the rapid development of new high technology materials, is the increased reliance industry will have on materials processing with remote sensing of materials characteristics to provide real time feedback to insure product quality and to improve cost competitiveness with both conventional and newer high technology materials. Research in materials processing will depend greatly on developing reliable data and process models to bring insight into the relationship between the physical and chemical properties of the material during processing and the functional or structural properties of the specific end-product material. This shift to real time materials characterization during processing will necessitate a strong and integrated Institute program in measurement research, materials data, modeling, nondestructive materials sensing, and the use of real time materials evaluation data in processing.

IMSE Plan

The Institute has recognized and participated in the worldwide shift in materials research to complement incremental improvements in basic commodity materials by research into new and advance materials designed specifically to satisfy functional or structural needs. Many of these materials were initially driven by specific defense, aerospace, communication or electronic functional needs. It has become apparent, however, that many of the new materials technologies may be adapted to produce materials with generally improved characteristics for commodity manufacturing. Most often, the barrier to industrial utilization of new materials with potentially improved characteristics is the lack of process technologies which yield uniform high quality at reasonable cost. Critical steps in the development of such process technologies are: measurements and related structural models to reveal the relationship between process variables, structure and properties; and sensors capable of real-time interrogation of materials properties during processing. It is in these measurement intensive areas that the expanded role for IMSE lies.

To continue it's leadership role in materials science research for the next decade, IMSE has developed budget initiatives within the NBS system to develop new measurement processes and data to allow the understanding, characterization and processing of high quality advanced materials. These initiatives will allow expansion of the Institute's traditional programs and build on the technical strengths in characterization of commodity materials. Initiatives developed and funded for the first time in FY 1986 allowed for the development of competence in the general area of advanced materials. Initiatives in advanced ceramics and in composite materials were formulated, presented to NBS and Department of Commerce management, and successfully approved by management and by the Congress. The first years' efforts were concentrated on developing the fundamental understanding of relationships between materials properties, structure and performance in advanced ceramics and high performance polymeric matrix composite materials. This program will expand into composite metal and ceramic matrix composites in the next two years if funding continues as planned. These new research areas coupled with redirected IMSE programs in powder metal technology, ultralight metal alloys, high temperature superconducting materials, and fundamental research in interface thermo-chemistry and structure represent the Institute's view of new crosscutting materials development programs in areas of importance to National needs.

The second successful initiative was the plan to develop a national facility for cold neutron research and measurements. This national facility will provide NBS, academic and industrial users the most advanced facility for measurement of materials at both atomic and macromolecular levels using neutron techniques. This measurement facility, coupled with other state-of-the-art measurement capabilities within the Institute, and within the National Measurement Laboratory, provide Institute scientists with world class measurement capability with which to study the composition/structure/property relationships of newly developed materials.

The third IMSE initiative, developed for consideration in the NBS FY 1990 budget, proposes developing advanced research capabilities in intelligent materials processing. This initiative emphasizes developing new process models and materials property sensors to allow dynamic control of process variables. The dynamically controlled processes will be designed to produce advanced materials economically and reliably and to achieve an enhanced level of quality in more conventional materials. The plan is to develop generic programs which integrate robust in-process materials property sensors with live-time process models to achieve a high level of material control. Multidisciplinary teams of investigators from appropriate parts of IMSE and throughout NBS will be assembled, with industrial participation sought at all stages of the effort, from planning through execution. The goal of these efforts is not the turn-key automation of a very specific processing machine, but rather the development of generic understanding of all of the elements required for automation of a class of processing equipment.

These initiatives coupled with the existing Institute programs in materials characterization and data, nondestructive evaluation of materials, and materials performance characterization provide the basis to interact with industry in improving the Nation's international competitiveness.

TECHNOLOGY TRANSFER

CONFERENCE PROGRAM
(SPONSOR OR CO-SPONSOR)

FISCAL YEARS 1986, 1987, 1988

ISO/TC 107/SC 3 on Coatings and Surface Finishings
April 7-11, 1986 (D. Lashmore--Metallurgy)
40 attendees

Establish international standards and test methods concerned with metallic and inorganic coatings with specific interest to critical metals and corrosion protection.

Crack Arrest Technology
April 10-11, 1986 (R. deWit--Fracture & Deformation)
40 attendees

Review the technological developments in dynamic fracture and crack arrrest. Transfer this information to electric power and gas industry.

NBS Analytical Chemistry/Materials Science Workshop
April 13-18, 1986 (J. Harris--Metallurgy)
50 attendees

To expose students and faculty of Historically Black Colleges and Universities to state-of-the-art research and analytical methods in chemistry and to present overview of current research activities in materials science and engineering.

Seminar on Micro-Analytical Techniques in Materials
April 21-22, 1986 (R. Fields--Fracture & Deformation)
40 attendees

Addresses current state of technology for determining microstructure and composition of metallic materials.

ASTM C14 on Glass and Glass Products Workshop
April 22-24, 1986 (M. Cellarosi--Ceramics)
40 attendees

To discuss cooperative standardization/measurement programs with NBS.

Interagency Coordinating Committee on Ceramics Meeting
May 6-7, 1986 (S. Hsu--Ceramics)
46 attendees

Review of current government sponsored programs in structural ceramics by government program managers.

Joint Services Technical Coordinating Group on Nondestructive Inspection (JRCG/NDI) Specifications and Standards Subgroup
May 6-7, 1986 (L. Mordin--Office of Nondestructive Evaluation)
15 attendees

To review progress on military standards and specifications for NDE.

IMSE Advanced Materials Symposium Series: Advanced Materials Characterization Using Synchrotron Radiation
May 28, 1986 (M. Kuriyama--Metallurgy)
100 attendees

To describe the recently commissioned IMSE x-ray beamline at the National Synchrotron Light Source to the scientific community of prospective users. The capabilities of the Light Source and the beamline instrumentation will be illustrated using recent research results.

Workshop on Materials Characterization by X-Ray Scattering
June 23-24, 1986 (C. Hubbard--Ceramics)
175 attendees

Status and future of industrial needs in materials characterization by quantitative x-ray powder diffraction methods.

Steel Sensor Workshop
July 16, 1986 (H. Wadley--Metallurgy)
30 attendees

Reported progress made on top priority sensor needs for the steel industry and outlined new directions for the steel sensor program.

Gordon Research Conference--Physical Metallurgy
July 21-25, 1986 (L. Schwartz--Institute Office)
85 attendees

The conference was organized around the topics of first order transitions, modulated structures and quasicrystals which have as a common theme the explication of structure in metals undergoing complex, and often novel, transformations. Both theoretical and experimental aspects were stressed with emphasis on recent x-ray and neutron scattering and electron microscopy results.

Gordon Research Conference--Solid State Studies in Ceramics
August 11-15, 1986 (B. Lawn--Ceramics)
100 attendees

Assessment of forefront developments in surface forces and microstructures as they apply to cracks and interfaces in ceramics.

ASM Materials Week 86--Sessions on the Effect of Coal Cleaning on Materials Performance
October 12, 1986 (S. Dapkunas-Ceramics)
20 attendees

Review the economics, technology, and science of coal cleaning and its effect on the performance of materials in coal combustion and gasification systems.

Universities Space Research Association Metals and Alloys Discipline Working Group
October 23-24, 1986 (S. Coriell-Metallurgy)
20 attendees

Discussions of metals and alloys research for microgravity science and applications.

41st MFPG Meeting - Detection, Diagnosis and Prognosis of Rotating Machinery
October 28-30, 1986 (R. Shives-Fracture & Deformation)
200 attendees

To improve reliability, maintainability, and readiness through the application of new and innovative techniques.

Workshop on Automated Processing of Rapidly Solidified Metal Powders by High Pressure Inert Gas Atomization
October 30-31, 1986 (H. Yolken/L. Mordfin-Nondestructive Evaluation and N. Pugh-Metallurgy)
40 attendees

To brief attendees and to solicit their views on establishing a consortium to develop a major new program on automated technology for the production of rapidly solidified metal powders.

2nd Interagency Tribology Research Coordinating Meeting
December 4, 1986 (S. Jahanmir-Ceramics)
20 attendees

Assessment of government programs in tribology and establishment of cooperative research plans.

IMSE Symposium Series on Composites: Fracture Behavior of Fiber Reinforced, Ceramic Matrix, Composites
March 19, 1987 (S. Freiman-Ceramics)
40 attendees

New test techniques were described which can be used to quantitatively determine fiber/matrix interface properties and to ascertain the role of crack/fiber interactions in governing the strength of the composite.

Workshop to Establish Standardization Plan for Real-Time Radioscopy
April 2-3, 1987 (T. Siewert-Fracture and Deformation)
25 attendees

To enhance the quantitative capabilities of industrial real-time radioscopy and to make its measurements traceable to recognized standards.

NBS-BAM Symposium on Corrosion and Wear
April 13-14, 1987 (W. Ruff-Metallurgy)
50 attendees

To offer communication between staff of the two organizations on research programs and projects. In addition, other professional individuals are made aware of research activities.

Interagency Coordinating Committee on Structural Ceramics
May 6-7, 1987 (S. Hsu-Ceramics)
45 attendees

To coordinate central objective of various Federal agencies on structural ceramic programs.

Third Annual Heavy Section Steel Technology Program Workshop on Dynamic Fracture and Crack-Arrest Technology
May 13-15, 1987 (R. Fields-Fracture & Deformation)
65 attendees

Results from on-going dynamic-fracture and crack-arrest studies around the world will be presented and discussed to stimulate technology transfer to US industry.

Joint Services Technical Coordinating Group on Nondestructive Inspection (JRCG/NDI) Specifications and Standards Subgroup
June 1-2, 1987 (L. Mordfin-Nondestructive Evaluation)
12 attendees

To discuss progress and plans and to coordinate interagency efforts to develop new and improved military standards and specifications for nondestructive evaluation.

COMAT Subcommittee on Superconductors
June 12, 1987 (S. Dapkunas-Ceramics)
40 attendees

Coordination of Government Sponsored Research on High Temperature Superconductors

ONR/NBS Workshop on Surface Forces
September 2-3, 1987 (B. Lawn/S. Wiederhorn-Ceramics)
25 attendees

Discussions on the application of new measurement technique to materials science.

U.S.-China Symposium on Advanced Ceramics Materials
September 8-11, 1987 (S. Freiman-Ceramics)
50 attendees

To exchange scientific information on advanced ceramic materials.

Workshop for U.S. Participants in IEA/Annex II Interlaboratory Comparison of Powder Characterization Methods
September 15-16, 1987 (A. Dragoo-Ceramics)
12 attendees

Discussion of technical issues related to physical and chemical characterization of ceramic powders.

ISO/TC164, Standards for Hardness, Uniaxial, and Fracture Testing
September 14-25, 1987 (R. Fields-Fracture & Deformation)
60 attendees

To establish international standards for mechanical testing.

42nd MFPG Meeting - Technology Innovation - Key to International Competitiveness
September 15-17, 1987 (R. Shives-Fracture & Deformation)
75 attendees

To provide a forum for the discussion of improving the position of the United States in the world market through the utilization of technology innovation.

ASTM E-49 Workshop on Ceramic Specification for Property Databases
September 29, 1987 (C. Hubbard-Ceramics)
10 attendees

To develop draft guidelines for specification of advanced ceramics for entry into a proposed materials property database.

Polymer Composite Processing and Industries Workshop
October 7, 1987 (D. Hunston - Polymers Division)
50 attendees

To expand the use of polymer composites by analyzing the critical need for improved processing.

Materials Science Symposium
January 14-15, 1988 (L. Schwartz-Institute Office)
150 attendees

To honor the 60th birthday of Dr. John Cahn.

Fatigue Data Workshop
January 19-22, 1988 (H. McHenry-Fracture & Deformation)
35 attendees

Addressed the collection, documentation, evaluation, and dissemination of fatigue data. Reviewed existing databases in the United States, Europe, and Japan and discussed documentation standards to permit the interchangeability of fatigue data.

VAMAS Steering Committee Meeting
January 22-23, 1988 (L. Schwartz-Institute Office)
30 attendees

To host the annual meeting of the international VAMAS Steering Committee.

Engineered Materials for Advanced Friction and Wear Application
March 1-3, 1988 (A. Ruff-Ceramics)
200 attendees

Application of engineered material to tribological situations.

Workshop on Microstructure and Macromolecular Research with Cold Neutrons
April, 1988 (C. Glinka; J. Gotaas-Reactor Radiation)
160 attendees

To inform the scientific and industrial community about the new cold neutron research capabilities at the CNRF and allow them to participate in the design and scientific planning of this new national center.

Low Temperature Structural Materials and Standards Workshop
May 26-27, 1988 (R.P. Reed-Fracture & Deformation), Tokyo, Japan
33 attendees

Establish international standards and test methods for structural alloys at liquid helium temperature to support the development of superconducting fusion energy magnet devices.

Gordon Research Conference on Tribology
June 20-24, 1988 (S. Hsu-Ceramics)
130 attendees

Review of most recent research in the field of tribology.

Conference on Thin Film Neutron Optical Devices
August, 1988, San Diego, CA (C. Majkrzak-Reactor Radiation)
50 attendees

Part of a symposium by the International Society for Optical Engineering to present and discuss the latest results in supermirrors, multilayer monochromators, polarizers and beam guides which are a key to the development of future cold neutron and x-ray scattering instrumentation.

Workshop on Intelligent Processing of Materials
August 30-September 1, 1988 (T. Yolken-Office of Nondestructive Evaluation)
56 attendees

To define the specific materials processes upon which the NIST Program should focus and to discuss suitable approaches for accomplishing the work.

NIST Workshop on Intelligent Polymer Processing
August 31-September 1, 1988 (A. Bur-Polymers Division)
25 attendees

To assess the needs of the U.S. polymer processing industry in developing inteligent polymer processing technology.

Mechanical Failures Prevention Group - 43rd Meeting, "Advanced Technology in Failure Prevention"
October 3-6, 1988 (T. Shives-Metallurgy), San Diego, CA
120 attendees

Materials Science of High T_c Superconductors: Magnetic Interactions
October 11-13, 1988 (L. Bennett-Metallurgy) (Co-sponsored by NASA)
120 attendees

Computerization of Welding Information
October 19-21, 1988 (T. Siewert-Fracture & Deformation)
63 attendees

Review the recent advances in software for welding application and develop a list of user needs to guide future software development.

Eleventh Cryogenic Structural Materials Workshop
October 18-19, 1988 (R.P. Reed-Fracture & Deformation), Colorado Springs, CO
50 attendees

To review, identify, and discuss important issues relevant to the advancement of structural devices for fusion energy developments.

Four U.S.-Japan Workshops on Dielectric and Piezoelectric Materials
October 31-November 2, 1988 (S. Freiman-Ceramics)
75 attendees

Cooperative summary of research results on electronic materials.

STANDARDS COMMITTEES MEMBERSHIP

Unit	Staff
Institute Office	3
Nondestructive Evaluation	1
Ceramics	16
Fracture & Deformation	11
Polymers	12
Metallurgy	21
Reactor Radiation	2
	66*

*Includes: 26 chairs
2 secretaries
1 director

Organization	Representation
American National Standards Institute	
American Nuclear Society	
American Society for Mechanical Engineers	
American Society for Testing and Materials	
Department of Defense/Technical Coordination	
Electronic Industries Association	
International Institute of Welding	
International Organization for Standardization	
Joint Committee on Powder Diffraction Standards	
National Association of Corrosion Engineers	
Safety Glazing Certification Council	
Welding Research Council	

Source: Directory of NBS Standards Committee Activities, 1988.

RESEARCH DISSEMINATION
FY 1988

UNIT	PAPERS PUBLISHED	TALKS INVITED	PATENTS*	SRMs*	MONOGRAPHS*
INSTITUTE OFFICE	17	29	---	---	---
OFFICE OF NONDESTRUCTIVE EVALUATION	11	5	---	---	---
CERAMICS	174	213	5	4	4
FRACTURE AND DEFORMATION	81	22	---	---	---
POLYMERS	154	88	8	3	---
METALLURGY	167	106	3	2	1
REACTOR RADIATION	101	27	1	---	1
TOTAL	716	490	17	9	6

*Listing on following page.

Patents Received or Pending

Aluminum Hydroxides as Solid Lubricants
Applied For
R. Gates, S. Hsu (Ceramics)

High Pressure Process for Producing Transformation Toughened Ceramics
Patent No. 4,771,022, September 13, 1988
S. Block, G. Piermarini (Ceramics)

Fibrous Monolithic Ceramic and Method for Production
Patent No. 4,772,524, September 20, 1988
W. Coblenz (Ceramics)

Ultraviolet Transmitting Glass for 308 nm Ring Dye Laser
D. Blackburn, D. Kauffman, D. Cranmer (Ceramics)

Novel Process for the Preparation of Fiber Reinforced Ceramic Matrix Composite
W. Haller, U. Deshmukh (Ceramics)

Dielectric Phantom Material
Applied For
M. Broadhurst, C. Chiang, G. Davis (Polymers)

Superconductor - Polymer Composites
Applied For
A. DeReggi, G. Davis, C. Chiang (Polymers and Ceramics)

Oligomeric Adhesives
Applied For
G. Brauer; C. Lee (Polymers)

Radiopaque Polymers Useful as Components for Radiopaque Materials
Applied For
G. Brauer, J. Stansbury, J. Tesk (Polymers)

Polymeric Denture Reline Materials
Applied For
R. Muller, J. Antonucci (Polymers)

Intaglio Ink Resins Which Cure by Oxidation in Air
In Process
B. Dickens, B. Bauer (Polymers)

Polymer-Reactive Photosensitive Anthracenes
Issued
Q. Tran-Gong, C. Han (Polymers)

Method of determining subsurface property value gradient
Patent No. 4,765,750 - August 23, 2988
H.N.G. Wadley (Metallurgy)

Concentration Gradient Alloys
Filled October 1988
D.S. Lashmore and M.P. Dariel (Metallurgy)

Trivalent Chromium
Issued October 1988
D.S. Lashmore, E. Weisshaus, E. Namgoong (Metallurgy)

New Matrix Approach to Crystal Symmetry
In Process
A. Mighell; V. Himes (Reactor Radiation).

SRMs PRODUCED

SRM 1835 Glass Analytical Standard
(Ceramics)

SRM 717 Glass Viscosity Standard Renewal
(Ceramics)

SRM 660 X-ray Line Profile
(Ceramics)

SRM 1879 Respirable Cristobalite
(Ceramics)

SRM 1496 Unpigmented polytehylene gas pipe resin
(Polymers)

SRM 1497 Pigmented polyethylene gas pipe resin
(Polymers)

SRM 388 Butyl Rubber
(Polymers)

SRM 1893 to 1896 and 1905 to 1907 Microhardness
(Metallurgy)

SRM 1357 to 1366 Coating Thickness
(Metallurgy)

MONOGRAPHS

Formation of Lubricating Films at Elevated Temperatures from the Gas Phase - NIST Special Publication 744, September, 1988
(E. Klaus, J. Duda, S. Haudi-Ceramics)

Vapor Phase Deposition Studies of Phosphate Ester on Metal and Ceramic Surfaces - NIST Special Publication 754, September, 1988
(D. Deckman, S. Hsu, E. Klaus-Ceramics)

The Design and Construction of a State-of-the-Art High Temperature Tribometer - NIST Special Publication 755, September, 1988
(J. Yellets, S. Hsu, E. Klaus-Ceramics)

Ceramic Tribology: Methodology and Mechanisms of Alumina Wear - NIST Special Publication 758, September, 1988
(R. Gates, S. Hsu, E. Klaus-Ceramics)

Brittle Fracture Behavior of Ceramics, Bulletin of the American Ceramic Society, February, 1988
(S. Freiman-Ceramics)

Proceedings 41st Meeting of the Mechanical Failures Prevention Group - "Detection, Diagnosis, and Progress of Rotating Machinery to Improve Reliability, Maintainability and Readiness Through the Application of Innovative Techniques
(T. Shives-Metallurgy)

Electron Diffraction Database
(Reactor Radiation)

APPENDICES

1988 PANEL MEMBERS

Dr. Francois A. Padovani,
Chairman (1990)
Vice President
Materials and Controls Group
Texas Instruments Incorporated
34 Forest Street, Mail Station 10/13
Attleboro, MA 02703
(617) 699-1102

Dr. Ian F. Hughes (1990)
Director, Product Research
Inland Steel Corporation
3001 E. Columbus Drive
East Chicago, IN 46312
(219) 392-3262

Dr. George R. Irwin (1989)
Department of Mechanical Engineering
University of Maryland
College Park, MD 20742
(301) 454-8856

Dr. Peter Juliano (1991)
Manager, Polymer Physics and
Engineering Laboratory
General Electric Corporate
Research and Development
P.O. Box 8
Schenectady, NY 12301
(518) 387-5874

Prof. Bernard H. Kear (1990)
Dept. of Mechanics and
Materials Science
College of Engineering
Rutgers University, PO Box 909
Piscataway, NJ 08855-0909
(201) 932-2245

Dr. Robert A. Laudise (1989)
Director
Materials Chemistry Research Lab
AT&T Bell Laboratories
Room 1A-264
600 Mountain Avenue
Murray Hill, NJ 07974
(201) 582-6220

Dr. John L. Mihelich (1989)
General Manager, Development (USA)
1200 Meidinger Tower
Louisville Galleria
Louisville, KY 40202
(502) 589-8100

Dr. Joseph N. Panzarino (1989)
Director of Research & Development
Advanced Ceramics
Norton Company
Goddard Road
Northboro, MA 01532
(617) 393-5820

R. Byron Pipes, Dean (1988)
College of Engineering
134 du Pont Hall
University of Delaware
Newark, DE 19716
(302) 451-2401

Dr. Maxine L. Savitz (1990)
Director, Ceramic Components Div.
Garrett Processing Company
19800 South Van Ness Avenue
Torrence, CA 90509
(213) 618-7569

Dr. Richard S. Stein (1991)
Commonwealth Professor of Chemistry
University of Massachusetts
Amherst, MA 01002
(413) 545-2727

Prof. Julia R. Weertman (1990)
Department of Materials Science
and Engineering
Northwestern University
Evanston, IL 60201
(312) 491-5353

Dr. Albert R.C. Westwood (1991)
Vice President - Research and Dev.
Martin Marietta Corporation
Martin Marietta Laboratories
1450 South Rolling Road
Baltimore, MD 21227
(301) 247-0700

An Evaluative Report on the
Institute for Materials Science and Engineering

PANEL MEMBERS

Francois A. Padovani, Texas Instruments Inc., Chairman
Edmund G. Henneke II, Virginia Polytechnic Institute & State University
Ian F. Hughes, Inland Steel Company
George R. Irwin, University of Maryland
Bernard H. Kear, Rutgers University
R. Glen Kepler, Sandia National Laboratories
G. S. Kino, Stanford University
Robert A. Laudise, AT&T Bell Laboratories
William J. MacKnight, University of Massachusetts
John P. McTague, Ford Motor Company
John L. Mihelich, AMAX Specialty Businesses
Joseph N. Panzarino, Norton Company
R. Byron Pipes, University of Delaware
Maxine L. Savitz, Garrett Processing Company
Sunil K. Sinha, Exxon Research and Engineering Company
David Turnbull, Harvard University
Julia R. Weertman, Northwestern University

This report, submitted for the Panel by the Chairman, Francois A. Padovani, is an annual assessment of the activities of the Institute for Materials Science and Engineering, based on a meeting of the Panel on January 21-22, 1988.

IMSE FUNCTIONAL STATEMENT

The Institute for Materials Science and Engineering (IMSE), a major organizational unit of the National Bureau of Standards (NBS), provides measurements, data, standards, reference materials, concepts, and other technical information fundamental to the processing, structure, properties, and performance of materials. This information is used by industry, government agencies, universities, and other scientific organizations. Much of it is made available through major new cooperative programs with industry, which ensure rapid dissemination and application of Institute technical output and provide Institute managers with immediate information on industry's needs for measurement science and data. The Institute, jointly with the ASM International and the American Ceramic Society, is evaluating and disseminating phase diagrams. The Societies provide guidance and substantial financial support from industry.

The research programs of the Institute support generic technologies in materials in order to foster their safe, efficient, and economical use. Research in the Institute addresses the science base underlying new advanced materials technologies. Rapid solidification of metals, ceramics processing, alloy coatings, polymer blends, and advanced composites are current examples.

The Institute has a beam line at the Brookhaven National Synchrotron Light Source for frontier research in materials transformations, kinetics, and advanced x-ray optics. Other unique facilities are made available to industry and universities in cooperative research projects. These include the NBS reactor and associated apparatus for the use of neutrons to characterize materials, laboratories for the preparation and characterization of rapidly solidified metal samples, and other state-of-the-art measurement facilities. The Institute collaborates with other NBS Centers and organizations in interdisciplinary programs in materials science.

During fiscal year 1988, the Institute had a staff of about 389 and a total operating budget of approximately $40.0 million.

EXECUTIVE SUMMARY

The quality of the staff and of the research performed are both excellent. The designation of NBS as one of the centers of excellence for the development of high temperature superconductivity is but a recognition of this fact. The excellent work performed by IMSE staff this year in high-temperature superconductivity was particularly evident in the poster session. The quality of this work is on a par with the innovative work of IMSE in the discovery and characterization of quasicrystals and the more recent development that provides improved understanding of pulsed alloy deposition and its application to form artificially layered structures. IMSE divisions continue to emphasize the good scientific research leading to the better measurement of new materials and processes. For example, their research on precipitate coarsening in rapidly solidified intermetallic alloys is very important scientifically and may prove of considerable technological importance. Their discovery of conditions that greatly increase the stability against precipitate coarsening of precipitation-strengthened aluminum-iron-base powder alloys provides the prospect that bulk parts could be made from these powder alloys without the loss of the useful properties imparted by their original rapid solidification.

These achievements, along with many more demonstrated accomplishments in ceramics, polymers, and composites are positive proof of the excellent performance of IMSE Divisions.

TECHNICAL REVIEW OF DIVISIONS

Ceramics Division

The Ceramics Division is responsible for providing scientific understanding, measurement methods, reference data, and materials to enable U.S. industry to achieve key properties of advanced ceramics through processing. Its work covers structural, electronic, and optical ceramics. The successful ceramic initiative in 1986 has enabled the division to grow and build competences in critical areas of national importance. The division management's effort in continual restructuring and focus has brought increasing visibility and reputation to the division. The responsiveness to the panel's suggestions and the extensive interactions with societies, industries, and universities have

brought much credibility and programmatic excellence to NBS. Overall, the Panel is pleased with the progress and the forward momentum of the division. The infusion of equipment, personnel, and the academic programs have led to high morale and productivity.

The quality and quantity of technical accomplishments continues to be excellent and growing. In three years, the division has become one of the major ceramic research centers. Through its many interactive programs with both the universities and industries, the division has emerged as the bridge linking basic research to applications. There are many accomplishments worthy of note. The following items, however, are selected.

The superconductivity work is of world class. The publications of the definitive phase diagram of the YBaCuO system is particularly significant. This is what people outside depend on NBS to provide. Elucidation of the many processing parameters, such as the influence of annealing conditions and sintered density on the superconducting transition temperatures, and the influence of milling media on superconducting phase composition, helps to define the superconducting material. This is much needed in this rapidly changing field.

The diamond film work is off to an excellent start. This is an extremely technologically important area and the division management is to be congratulated in moving into an emerging area with speed. Verification of an uniform diamond film deposition is impressive in such a short time.

A theory to explain the observed rising fracture toughness (R-curve) of monophase ceramic materials with growing crack size has been developed. The source of the toughness of ceramic materials originates in interlocking grains and unbroken ligaments that cross between the crack faces. These apply a closure force to the crack that must be overcome for fracture to proceed. This theory implies that the toughness of ceramic materials can be enhanced by microstructural design to increase the degree of interlocking of fracture forces. This analysis could have significant impact on structural ceramics development.

The National Bureau of Standards - Ceramic Society (ACerS) ceramic phase diagram program completed its second full year of the expansion plan. This joint program is the response to industry's growing need for broad coverage of ceramic systems and a more current, evaluated data compilation. The first evaluated data output from the program, Volume 6 of Phase diagrams for Ceramics, was completed and turned over to ACerS for printing. This volume contains 697 commentaries and 1080 binary, ternary, and high order phase diagrams of oxides, metals plus oxides, and metals plus oxygen. The completion of this Volume, produced using computer graphics and database systems, is a major contribution to the ceramic industry.

Fracture and Deformation Division

Progress and objectives of the IMSE Fracture and Deformation Division are productive and well balanced. Division members have successfully continued investigations of structural failures, flaw detection using nondestructive evaluation (NDE), relationship of NDE signals to composite properties, deformation behavior of cryogenic materials, and improved understanding of fracture mechanics measurements. The various organizational changes undergone by the Division during the year appear to have been well accepted and not to have changed the high morale. Transfer of a Division Group concerned with ceramic materials to the Ceramics Division several years ago and recently of a group to the Metallurgy Division leaves the Fracture and Deformation Division with no operating components in Gaithersburg. The prior arrangement had value in terms of promoting close liaison between NBS Gaithersburg and NBS Boulder. However, other liaison techniques are available and will, presumably, be used. The current Division Chief has a strong interest in enhancing the commercial relevance of NBS expertise. Both the experience of the staff and the location of NBS Boulder can be an advantage in developing and transferring advanced technology of import to domestic industry.

NDE-related activities of the Fracture and Deformation Division possess a commendable balance of basic and applied research. Some of the applied research has specific applications--for example, automated crack detection in railway car wheels. Specific measurements are conducted in parallel with the development of improved NDE methodology and with special attention to new methods as shown by the development of a capacitive array device applicable to dielectric materials. Use of ultrasonic techniques to reveal modulus and texture properties has been carried forward with applications to ductility of aluminum sheet material, texture in controlled rolling of low-alloy steels, and residual stress from welding. NDE-related research is closely linked with analytical models being developed in the Physical Properties Group and others. Studies include composites and new superconducting materials. The depth of understanding provided in this way is excellent and provides guidelines for research and programmatic planning.

Investigations of welding have made progress in understanding the quality of arc welding. For example, in steels used at cryogenic temperatures, unstable yielding was noticed at high strain rates that correlates with specimen warming caused by the transition from nucleate to film-boiling heat transfer.

Fracture investigations have substantial scope and are directed toward topics of advanced current interest; cleavage-fibrous transition behavior, analysis of surface cracks, and improved criteria for crack extension by hold-joining. Separation from the Division of run-arrested studies of wide plates at Gaithersburg (conducted in cooperation with the Nuclear Regulatory Commission High Strength Steel Testing Program) should not deter the Division from a continuing interest in dynamic aspects of fracturing. The largest application is with materials and plate thicknesses that differ substantially from those of main interest for nuclear plant vessels.

Research of the Fracture and Deformation Division is assisted by close contacts with a number of universities and other-agency laboratories. The advantages are mutual. Research staff quality attracts outside interest and promotes symbiotic cooperative research ventures.

Polymers Division

The Polymers Division is responsible for providing standards, measurements, and fundamental concepts of polymer science to assist U.S. industries that produce, process, or use synthetic polymers as an essential part of their business. In order to identify specific technical programs to address this broad mission, the Division's management looks for trends in the industries concerned and tries to anticipate future needs. In recent years, the Division has been working toward a major activity in high performance composites and that activity has now been partially funded.

The quality and quantity of technical accomplishments continues to be very high. The Polymers Division at NBS is probably one of the four strongest polymer physics groups in the United States. The recent loss of one of the scientists was a serious blow to the group, however, and it is important to recruit a theoretician with the potential to make up for this loss.

A few examples of accomplishments during the past year include:

An NDE measurement technique for determining the total charge trapped within a polymer film has been devised to complement the Division's ability to determine the spatial distribution of the charge. Experiments with polyethylene, zinc ionomers of polyethylene-methacrylic acid copolymers, and blends of the two all show nearly uniform distribution of negative charge after charging to steady state conditions with an applied electric field. An important application for polymers is as dielectrics in a wide variety of high electric field applications such as power distribution cables, and a major goal of this work is to develop a more fundamental understanding of high voltage breakdown in polymers as well as techniques for making measurement pertinent to the problem.

A percolation model was successfully applied to a theory of network formation and thermosetting composite resins where crosslinking reactions are not dominated by linear polymerization reactions. Neutron scattering and computer modeling results confirmed the applicability of the theory. Thermosetting resins are widely used in composites, and fundamental knowledge of the polymerization reaction will be very important in guiding studies of composite processing.

The Cahn-Hilliard-Cook equation has for the first time been proven to be quantitatively correct. The equation was applied to spinodal decomposition of a polystyrene/poly(vinylmethylether) blend system. Data verifying its accuracy came from time-resolved temperature jump and reverse quench light scattering techniques, and from a structure factor measured by a small angle neutron scattering experiment. It is generally believed in the polymer community that many of the new polymers required to meet future needs will be

prepared from polymer blends rather than by synthesizing new molecules. Thus, fundamental understanding of the phase separation process represented by this work will be crucial for the development of these new materials and for the development of standards and processes pertinent to the industry.

Metallurgy Division

While continuing its traditional activities in measurement science, materials characterization, and data programs, the Metallurgy Division has seen the development of two major new thrusts in recent years. The first is in processing, an area of direct relevance to the growing NBS mandate to assist U.S. industry; the focus on process sensors is well chosen, given the Bureau's measurement-science niche. The second thrust, characterization of advanced materials, is also fully consistent with the NBS mission, and the development of these emerging technologies is clearly critical to the Nation's future competitiveness. This new focus has not led to the abandonment of programs on traditional materials such as steel and aluminum, where the emphasis has shifted appropriately to processing; because of the large markets, incremental improvements in the processing of these materials can be extremely valuable. The Division has also maintained a strong effort in data programs and standard reference materials. The success of the ASM International-NBS program on binary alloy phase diagrams, now nearing completion, is particularly gratifying. The newer program with the National Association of Corrosion Engineers on corrosion data promises to attain the same high level of service to the materials community.

In the processing area, the development of sensors for measurement and control of particle size and distribution during powder atomization is singled out for special note. The need for such sensors is urgent; the full potential of near net shape technology will not be realized until sensors are available for on-line control of the complex atomization process. The recent establishment of the consortium with three industrial partners underscores this point, and provides a valuable model for further collaborative programs between the Division and industry. The use of laser scattering techniques to measure particle size appears promising, as is high speed photography to yield information on the breakup of the molten metal stream by the high pressure inert gas. Ultimately, detailed knowledge of the process will lead to identification of the key parameters which control atomization. Selection of powder atomization for the Division's entry into the field of intelligent processing is a sound choice, as is the decision to enlist the collaboration of computer control specialists from other NBS Centers rather than attempt to develop this capability within the Division. The ultrasonic and eddy current work on sensors to measure internal temperature of steel and aluminum during thermomechanical processing continues to be exciting and should be encouraged.

The selection of metal matrix composites (MMC) as one of the advanced materials to be studied is sound. The cooperative work with American Cyanamid Corporation on the application of electrodeposition to the fabrication of fiber reinforced MMCs is highly innovative, but the Panel notes that this approach will face strong competition from the chemical vapor deposition

process. The emphasis on NDE for such materials, particularly for probing the interfaces, is the right focus.

The Division has also seen some re-structuring of staff in recent years, both from transfers of groups to and from other Divisions and from staff reductions. However, the quality of work has remained high and the Division is now better positioned to pursue a program which conforms closely to the evolving NBS mission.

Reactor Division and Office of Nondestructive Evaluation

The activities of these units were reviewed by separate panels. Appendix 1 gives the panel report on the Reactor Division and Appendix 2 that for ONDE.

LONG-RANGE PLAN

Comments on Plan

The proposed legislation to create a National Institute for Standards and Technology (NIST) will challenge NBS to broaden its role in the national industrial environment. The need for a long-term strategy plan outlined in last year's report has thus been greatly enhanced. The present IMSE long-range plan focuses on well developed tactics. The IMSE staff is commended for this first step. However, in the absence of a vision of where materials science and engineering will be in the year 2000 and of the role of NBS and IMSE in achieving this vision, it is very difficult for the Panel to assess the appropriateness of the proposed tactics.

If legislation creating NIST becomes law in 1988, NBS will have to accept major additional responsibilities while maintaining excellence in science and standards. The importance of the NBS former role must not be decreased or eliminated and NBS must continue to serve as a catalyst, referee, and scientific basis for standards, for test methods, and for materials. This traditional role of NBS is key not only to ensure smooth trading of products and services in the national and international markets but also to form the base for continual quality improvements in U.S. manufacturing processes.

The needed long-range plan cannot be achieved without inputs from the industrial environment. Such inputs should be sought either through direct contacts by IMSE staff or through special symposia on the future of materials science and engineering. The Panel is glad to see that activities of this type in the very advanced areas of materials science are being encouraged.

The Panel recommends that, following these inputs, a yearly planning function be established. This function could bring together IMSE management and staff and the Panel for a session responsive to last year's request by the Chairman of the Board on Assessment of NBS Programs to the Panels, to assess the needs of the very important high technology industries.

Comments on Initiatives

Automated Processing of Materials Initiative

IMSE must be commended for the proposed automated material processing initiative, an initiative that emphasizes the science of processing rather than expecting to directly couple to a specific factory. Processing is clearly an area that needs more emphasis in U.S. research. The Panel believes that the IMSE scientists could have a significant impact on some processes by working closely with industry in determining what in-process measurements need to be made to understand the behavior of materials under process conditions. This initiative requires an interdisciplinary approach within NBS and IMSE in a manner similar to the approach being taken in the composites initiative. The clear challenge is to develop generic concepts in the face of a great diversity in materials processing approaches. The Panel is concerned about the large number of processes currently under consideration. While the choice of which process to use as a test bed is not evident from the data presented, the choice should be made with care and with industrial input. Such an input could be obtained from a series of ad hoc workshops.

Composite Initiative

The use of organic matrix composite is growing at a rapid rate worldwide, but composite processing still tends to be an art. Some time ago NBS identified composites as a critical emerging technology, and the IMSE divisions have devoted considerable effort to the evaluation of the possible role and potential impact of an NBS program and to the planning and organization of the NBS effort.

The Panel strongly supports this initiative, particularly the decision to focus initially on processing and on-line measurement techniques for process controls. This focus will effectively use the Polymers Division expertise in polymer fundamentals and measurement technology.

A workshop was held in an effort to learn the concerns of industry. The attendees included composite users, suppliers, and fabricators from a wide range of industries. Despite the diversity of industries represented, the workshop was able to identify and rank the processing methods that industry believes will be important in the future and to determine the scientific and technical barriers that hinder the implementation of these techniques.

The Panel applauds these efforts to keep abreast of the needs of industry and would encourage other efforts, including industry processing site visits, short (1 day) to long (6 months or more), as well as encouraging industry to provide composite processing specialists to work with NBS scientists. Such activities will help to keep the industry needs current in the minds of the researchers and will aid in the transfer of pertinent technology developed. For the future health of the initiative, it is important that some short-term goals and impact be achieved, and close collaboration with industry should make that possible.

The mechanical properties of polymer composites are, however, inextricably linked to the processing of the material. A comprehensive composite program must, therefore, couple research on processing with measurement and understanding of the useful mechanical properties. This part of the program is the subject of a fiscal year 1989 budget initiative. The panel strongly endorses this initiative and considers it vital to the program.

The Panel notes also that the composite initiative appears to lack a ceramic component. The United States has launched a major effort in whisker- and fiber-reinforced ceramic matrix composites and is currently leading the Japanese in composite technology. The type of infrastructure being developed for composites under the composites initiative is greatly needed for ceramic composites as well. This Panel strongly recommends that measurement techniques, standards, theory, mechanical properties (as a function of temperature), reinforcements, and interfaces, etc., relevant to ceramic matrix composites, be included in the composites initiative.

PANEL CONCERNS

The Panel is concerned about the apparent gradual shift away from the traditional role of NBS and IMSE as developer and keeper of standards. This NBS mission is critically important to the U.S. economy. Without reference standards not only can commerce not flow in a smooth and efficient fashion but research on new material systems, such as the newly discovered high-temperature superconductors, can be delayed considerably. The Panel believes that the level of IMSE standards effort, such as data compilation may be inadequate to meet the needs of U.S. industry, academic, and various government endeavors.

There appears to be a lack of support for the data centers. National data centers for materials properties are a much-needed asset to our nation. Emphasis should be placed on this fundamental role of NBS to support the gathering, analysis, and diffusion of standard material characteristics so vital to the industry. It is gratifying however to see how much progress has been made by NBS/ASM and NBS/ACerS in providing a compendium of metals and ceramic phase diagrams. Also, the National Association of Corrosion Engineers/NBS Corrosion Data Center continues to provide a valuable service to the materials community. It will be interesting to see how the proposed Tribology Data Base program develops. But more is needed. For example, in the area of ceramic technology, much has been learned through research in the U.S. about fracture toughness, tensile testing, and creep. A considerable body of scientific and engineering data is now available at NBS and elsewhere concerning the properties of ceramic materials both at room temperature and at high temperature. The Panel recommends that NBS take an aggressive role in collating, augmenting as necessary, comparing and evaluating these data in order to issue recommended procedures with supporting rationale for fracture toughness and tensile strength for both monolithic and ceramic composites at room and elevated temperatures. Such data are badly needed throughout industry. Performance of this task in a timely manner will aid fledging efforts of the ASTM in advanced ceramics to be successful in real time.

The Panel also is concerned that IMSE is essentially not involved in research on semiconductor materials such as silicon and the III-V compounds. Such materials are the linchpin of modern electronics. At present, semiconductors are the responsibility of the Center for Electronics and Electrical Engineering. While there is good logic for this arrangement, the experience of many other laboratories is that, unless semiconductor research has a materials base and sponsorship and unless even device coupling is good, depth, sophistication, and intellectual content usually suffer. A mechanism to ensure adequate treatment of electronic materials is essential as IMSE moves toward processing science. Declining electronic competitiveness is largely due to neglect of processing. Industry is beginning to realize this and is now ready to listen. IMSE could make a contribution and should consider an initiative in this vital area.

The Panel notes further that fracture, or separational mechanics, is an interdisciplinary phenomena and that fracture investigations of various kinds are conducted in at least three IMSE Divisions in two geographically separated areas of the country. For such interdisciplinary topics, an annual summary report, indicative of the total NBS program appears appropriate.

APPENDIX I
An Evaluative Report on the
Reactor Radiation Division

Panel Members

John P. McTague, Ford Motor Company, Chairman
Michael E. Fisher, University of Maryland
Sunil K. Sinha, Exxon Research and Engineering Company
Julia R. Weertman, Northwestern University
Max L. Yeater, Rensselaer Polytechnic Institute

This report, submitted for the Panel by the Chairman, John P. McTague, is an annual assessment of the activities of the Reactor Radiation Division, based on a meeting of the Panel on November 24-25, 1987.

Functions of the Division

The Reactor Radiation Division (RRD), a part of the Institute for Materials Science and Engineering (IMSE), manages a national center for the development and application of neutron methods for the characterization of advanced materials important in science and technology. The Division operates a 20-MW research reactor (NBSR) and conducts diverse programs in materials research, while fostering extensive collaboration with other NBS divisions and with outside scientists and engineers from industries and universities and other government laboratories who need neutron techniques for their own research and development efforts. A primary goal is to achieve maximum utilization of the many available facilities at the NBSR as a national resource for U.S. science and technology.

During fiscal year 1988, the Division had a staff of about 40 and a total operating budget of approximately $5.2 million. The cold neutron source installation had a staff of 5 and a total operating budget of approximately $1.4 million.

Despite the fact that the RRD and NBS are each more than 20 years old, both are in the midst of a multiyear period of major growth and diversification.

Reactor Power Upgrade

For the first 16 years, the NBSR operated at 10 MW and became a major center in the United States for reactor neutron research with extensive collaboration with many universities and other government agencies. In 1979, after several years of budget initiatives, funding was obtained to double the reactor power to 20 MW. An extensive process of preparing a completely new Safety Analysis Report and an Environmental Impact Statement that was required in order to amend the NBSR license. The new license was issued in May 1984, modifications

were completed during the following year, and 20-MW operation commenced on April 3, 1985. This doubled capability made the NBSR facilities fully competitive on a national basis. The substantial external collaborations grew including stronger ties with industry.

Cold Neutron Source

The promise of 20-MW operation encouraged a careful look at the potential for other long-range facility enhancements. And, in 1983, a proposal was put forward to develop a Cold Neutron Research Facility (CNRF) including a large cold neutron guide hall. The first stage--the development and installation of a cold neutron source and related scientific and technical support--was funded in fiscal year 1985. Because of the wise original design of the NBSR, the cold source could be very large. The large size of the cold source and the configuration of the accessing beam ports permits a large number of neutron guides. The cold source consists of a vacuum-insulated cryostat filled with about 17 kg of heavy-water ice. The cryostat is shielded with lead and bismuth to minimize the heating by core gamma rays, and the whole assembly is inserted in the reactor. Installation was completed in August 1987, and beneficial operation started in September of that year.

Cold Neutron Research Facility

The second stage of the CNRF proposal was approved by Congress in fiscal year 1987. This stage will provide a new CNRF at the NBS reactor with a full complement of 15 experimental stations. The facility comprises seven cold neutron guides that look at the recently installed cold source and extend through the existing reactor confinement building wall into a neutron guide hall 100 ft wide by 200 ft long, 15 experimental stations, and a new office and laboratory support building. The final architect/engineer design was started early in fiscal year 1987, and the official groundbreaking was held November 20, 1987. The civil construction phase of this facility is now well under way, with building occupancy scheduled for January 1989. At that time, installation of the neutron guides can begin, and the first experimental stations can be assembled starting in approximately July 1989. The contract for the neutron guides is scheduled for signing in February 1988, with first delivery scheduled for early 1989. All activities are on schedule.

Instruments to be installed at the facility are of two classes--two-thirds to be built entirely by NBS as part of the project, and one-third to be built by participating research teams (PRTs). For the first class, NBS will receive one-third of the available time on the instruments for programmatic research, with the remaining time reserved for the external U.S. research community. For the second class, PRTs will receive two-thirds of the available time, with the balance being reserved for outside users. There will be no charge for the use of the instruments or neutron beams for research to be published in open literature. Proprietary research meeting NBS criteria may be performed at full cost recovery by NBS.

RRD staff are currently designing the first five proposed instruments. The small-angle neutron scattering (SANS) spectrometer is furthest along. The time-of-flight spectrometer, triple axis spectrometer, backscattering

spectrometer, and the reflectometer are in varying stages of design. The SANS spectrometer is being built by a PRT, NBS, and the Exxon Research and Engineering Company. This arrangement will probably prove to be a model for most other PRTs. NBS will participate; even though there is no requirement for NBS to do so.

The Panel fully supports the PRT concept as a means of collaboration with major external users, and as a resource for the scientific and engineering community as a whole.

Staff Increase

The Division has started to increase both scientific and technical staff for the cold neutron project, which provides funding and slots for 30 new hires. This increase is required to allow the facility to be operated as a national user facility, and the early start on hiring has been essential to instrument design. On the technical side, one new mechanical designer and three new technicians have been added to date, and at least three additional technical staff are scheduled to be added in the coming year. Six new scientific staff members with varying levels of experience have been added: an expert in time-of-flight spectroscopy; an expert on neutron optical devices and magnetic scattering; a scientist with experience in neutron scattering and extensive experience in light scattering; a surface scientist with some neutron scattering experience (hired after completion of a National Research Council (NRC) postdoctoral appointment at NBS); a recent Ph.D. recipient with expertise in neutron and x-ray scattering research; and a scientist trained in neutron scattering, who also was hired after completing an NRC postdoctoral at NBS. These staff additions have had a large impact on the Division, and NBS has the youngest staff at any of the national centers in neutron scattering research. Combined with the senior staff, the mix of youth and experience ensures a combination of both vigor and judgment in both research and instrument design. The Panel fully supports this staff expansion.

External Users Increase

Use of the neutron scattering facilities at the NBS Reactor increased dramatically over the last decade, by a factor of almost three. The steady increase has been stimulated in part by the upgrade to 20 MW as well as to the development of the small-angle scattering facility, the high-resolution powder diffractometer and other neutron instruments. During fiscal year 1987 some 220 scientists from all over the United States and many foreign countries participated in neutron scattering research at the NBSR (140 "hands-on" users) out of a total of 339 participants in all research applications at the NBSR. The number of users of the neutron facilities at NBS is currently as large as at any neutron center in the United States and includes scientists and engineers from over 80 corporations, universities, and government agencies.

Another impressive aspect of the growing user community at the NBSR is the diversity of scientific applications that have been stimulated by NBS staff over the past decade. Perhaps more than any other U.S. neutron center, the programs and user policies at NBS have expanded the range of disciplines and research areas affected by neutron methods beyond their traditional

critical role in condensed matter physics and crystallography. During this period, RRD staff along with NBS and outside colleagues, have established a leadership role in both experimental and theoretical materials science, including the study of the structure and microstructure of ceramics, alloys, and microporous materials, and the use of energy-dispersive diffraction techniques for three-dimensional studies of residual stress in metal products and composites. In addition, NBS has had the strongest U.S. effort in the application of neutron spectroscopy as a sensitive probe of molecular bonding and dynamics in and on catalysts.

Much of this success in fostering new developments and applications in neutron research is due to the very broad role of 15 other NBS divisions in research at the NBSR (over half of the experimental facilities at the reactor are operated by groups outside the RRD). All of the Divisions in IMSE have active research programs in the neutron facility. The neutron facility is a cornerstone for the NBS program in materials science. For example, the Polymer Division has established one of the major efforts in the United States in SANS research on polymer blends and epoxies. Another example is the Center for Analytical Chemistry's outstanding work in developing neutron depth profiling as a unique nondestructive method for studying key near-surface impurities in semiconductor devices and thin films. Again, the Panel would cite the combined theoretical and experimental research by the Reactor and Ceramics Divisions and by the Center for Analytical Chemistry in developing advanced methods for pore structure studies in microporous and ceramic materials. This diversity of NBS neutron research efforts, which is also reflected in the several NBS centers outside of IMSE engaged in developing new cold neutron research instrumentation, should be of great benefit in fostering a diverse national user community at the CNRF and is strongly endorsed by the Panel.

Emerging Role as a National User Facility

As a result of the Cold Neutron Facility, the character of the Division's interactions with the outside community will change substantially. Although there has always been substantial interaction between the Division's programs and other researchers both inside and outside NBS (interactions are detailed elsewhere), the new facility will be operated as a national user facility, with free and open access to all qualified researchers in the United States. A large fraction of the time on the new instruments will be allocated by a program advisory committee on the basis of scientific merit, with no requirement for collaboration with the in-house staff. This will necessitate significant changes in the nature of the Division, including significant staff increases to assist outside users in doing experiments. It will also require that the Division staff make a large effort to seek the advice and guidance of the user community, and especially, to broaden this community. This process has been started, with one workshop on fundamental neutron interaction held in 1986, and a second on microstructure scheduled for April 1988. In addition, several staff members have given lectures on the new facility at universities, industries, and other government agencies. A biannual newsletter will be sent to the user community starting in late spring.

The Panel encourages RRD to accelerate user community involvement by early formation of user groups and by a truly broad promulgation of a statement describing NBSR as a national user facility. Consideration should be given to setting up a national advisory committee containing prominent scientists and engineers not necessarily confined to those with strong personal interests in neutron scattering per se. This action should be taken as soon as possible, to assure broad input into the development of the user mode.

Summary

All of the above changes are important for RRD, for NBS, and for the overall national research and development effort. The pace and the quality of progress are encouraging and reflect favorably on the high priority that NBS management has placed on these growth areas. The expansion of the scope ofthis major facility offers the promise of helping further to focus and define the character of NBS both internally and externally, nationally and internationally.

APPENDIX II
An Evaluative Report on the Office of Nondestructive Evaluation

Panel Members

Gordon S. Kino, Stanford University, <u>Chairman</u>
Laszlo Adler, Ohio State University
Peter Bridenbaugh, Aluminum Company of America
Spencer H. Bush, Review and Synthesis Associates
Joseph A. Giordmaine, AT&T Bell Laboratories
Edmond G. Henneke, II, Virginia Polytechnic Institute and State University
Robert W. McClung, Oak Ridge National Laboratory

This report, submitted for the Panel by the Chairman, Gordon S. Kino, is an annual assessment of the activities of the Office of Nondestructive Evaluation, based on a meeting of the Panel on November 16-17, 1987.

Functions of the Office

The Office of Nondestructive Evaluation (ONDE), a part of the Institute for Materials Science and Engineering (IMSE), provides for enhanced reliability, productivity, and economy in the use of materials, structural components, and systems, both during their manufacture and in service by conducting research leading to the development, stimulation, and dissemination of (1) more sensitive and reliable nondestructive evaluation measurement methods; (2) improved NDE physical measurement standards, calibration services, and document standards; and (3) information to relate NDE measurement results to material and systems properties and performance.

During fiscal year 1988, the Office had a staff of about 6 and a total operating budget of approximately $2.4 million, of which approximately $1.8 million was a congressional appropriation, $462,000 was from other agencies, and $155,000 was obtained from industrial sources.

Organization

Nondestructive evaluation is an interdisciplinary field. It requires knowledge of such subjects as materials processing, signal processing, optics, acoustics, and a broad range of physics, as well as the techniques for applying the basic principles to field applications.

The organization of the ONDE, requiring a wide range of talents, has a permanent nucleus to manage the interdisciplinary programs and to recruit the necessary talent from the relevant parts of the NBS. They typically use a core of people with a long and productive background in the field of nondestructive evaluation, along with others on a less-permanent basis, who are needed to address particular problems of interest.

ONDE, by drawing upon the interdisciplinary resources available within NBS, has devised a constructive approach for tackling the problems of nondestructive evaluation. Such efforts are often difficult to implement in university or, for that matter, industrial research settings. The Panel is most enthusiastic about the way this has been done at NBS and believes that the approach carried out by the ONDE is working extremely well.

Strategic Plans and Goals

Support for this program has been approximately constant in dollars during the last 4 to 5 years. This represents an effective decrease in the operating budget of the order of 20 to 25 percent during the same period.

This Office has pioneered the application of NDE to material processing and has brought to the attention of the industrial community the possibility of using NDE techniques for automated manufacturing. The Chief and Deputy Chief are to be complemented on recognizing this need very early on, and on writing papers and holding workshops to alert the country to this need and opportunity. The basic idea that they presented was to measure critical material and structural parameters during the manufacturing process, and to use these measurements in a feedback loop to control the process itself. The development of sensors and appropriate techniques of NDE, as well as the development of control systems and suitable computer algorithms for the purpose, is required.

Previous Panels urged the ONDE to develop a strategic plan. They have done this and have reduced the number of programs from 52 in 1985 to 21 in 1987. These programs are formulated around four subjects: (1) NDE for ceramic and metal powder production and consolidation, (2) NDE for formability of metals, (3) NDE for composites and interfaces, and (4) NDE standards and methods. In this report, the Panel discusses aspects of each one of these programs.

NDE for Metal and Ceramic Powder Production and Consolidation

The largest part of the program on automated materials processing is a study of powdered metal production; this project has been in place for approximately 1 year. The Panel believes that this program on automated materials processing is demonstrating the leadership that NBS has exerted in this field and is one of great importance to the country. The basic idea is to measure droplet formation and particle size in the production of metal powders in an atomization system and to modify the parameters of the system by process feedback control. A consortium of three industrial firms is working closely with NBS on this project. The consortium has contributed approximately $200,000 per year, and funding from NBS is on the order of $250,000.

An industrial consortium is an excellent conduit for funding in a tight funding situation. In addition, it is a fine vehicle for the transfer of technology. Projects of this kind should not, in fact, be encouraged unless there is suitable industrial participation. NBS has made a very good start on this project, and the participants understand where they are going and what they must do. The initial measurement work with the production system, which

cost approximately $1 million, has gone well, and the basic measurements that are needed on how the diameter of the powder particles varies with such parameters as input pressure of the gas, temperature, and properties of the nozzle, have been made. In addition, theories have been performed on turbulent flow that appear to predict the kind of behavior expected. They have not yet made much of a start on the control system and the theoretical background needed for this purpose; however, this should not be expected in the first year. It is hoped that this part of the program will start in the next year.

Another outstanding program is the Ultrasonic Characterization of Ceramic Processing. For the first time, ultrasonic methods have been used to measure the properties of green ceramics while they are being formed under pressure. The differences between normal and calcined materials have been determined ultrasonically, and the measurements appear to be able to give good predictions of the final mechanical properties of the material. The Panel believes that this work is a very important contribution to the material processing of ceramics.

NDE for Formability of Metals

One program, worked out in cooperation with the American Iron and Steel Institute (AISI) on temperature sensors, has been fully transferred to AISI. This has had several changes in direction along the way. Battelle Northwest Laboratories is using the science base generated by NBS, but modified to use two electromagnetic acoustic transducer systems. It remains to be seen how successful it will be in the demonstration now under way in a steel mill.

Another very simple eddy-current technique on the measurement of temperature of aluminum rods appears to be very successful. Another program on the measurement of surface roughness uses a very simple acoustic technique to measure surface roughness while a metal sample is being turned or milled.

NDE for Composites and Interfaces

NDE for Composites and Interfaces is the weakest of the four programs now being pursued by ONDE. Although some good fundamental work on polymer matrix processing is being carried out using fluorescence techniques, the relation between this program and the NDE problems of epoxy composites, let alone metal matrix composites, has not been well thought through.

One possible solution is to decrease the effort in this field. However, this type of research is of such importance to the country that, if anything, the effort should be increased, not decreased. NBS needs better plans for more measurement and management expertise on composite research.

NDE Standards and Methods

This is a fundamental direction of research and development to which NBS has always been the major contributor. The work proceeds well, particularly the acoustic emission work. NBS appears to be interacting well with the American

Society of Testing and Materials and other organizations in the NDE field with which they should have good contact.

Technology Transfer

The transfer of technology, when industrial people are involved, appears to go fairly well, and this group at NBS has shown a penchant for technology transfer. Small projects in which industry is not involved, however, are far more difficult to transfer. The IMSE is encouraged to find new mechanisms for the transfer of such technology. Early application for patents may help in order to give small companies protection when taking on a new project of this kind. Another possible mechanism is a technology fair in which some of these ideas could be exhibited to industry. Attention to technology transfer by the NBS office devoted expressly to this purpose may be helpful.

New Initiatives

The ONDE is formulating a strategic plan for automated processing of materials. As discussed earlier in this report, a project on automated metal powder production has been started and is going well. ONDE has discussed with the Panel the possibility of extending this concept for several types of material processing production problems and described to the Panel a list of 10 projects that they were considering.

The Panel strongly supports the basic idea that was pioneered several years ago by the Chief and Deputy Chief to use NDE for automated processing of materials. It is anticipated that such studies will enhance U.S. production efficiency in sophisticated materials. NBS is well situated to carry out such a program and has many of the basic components that are needed in place. These include nondestructive evaluation necessary for the sensors, a manufacturing facility, background in materials processing, good contacts with industry, and experience with technology transfer. There is considerable strength at NBS in the Center for Manufacturing Engineering in the systems and control aspects of this kind of problem; it would be necessary to increase the interactions and management capacity in the ONDE in this direction. The Panel strongly encourages this initiative to increase the effort in automated materials processing. It should be possible to add two or three programs of this kind in the next few years, provided that necessary funding is available. Such funding should not be provided at the expense of the current ONDE program, which is of vital importance to NBS and to the country.

Because programs of this kind should be chosen very carefully, a set of criteria needs to be established. Some possible criteria that the Panel has discussed are as follows:

1. An automated production system should have a major impact and be competitive. For example, new automated techniques for a labor-intensive industry, such as shipbuilding, is not likely to be worthwhile. A country such as Korea, with very low labor rates, could probably have a more cost-effective production system without using such a sophisticated approach.
2. There must be industrial interest in the project.

3. There must be a national need for the project.
4. There must be in-house expertise at NBS in the material processing application being considered, and a natural niche into which NBS can fit.
5. The relation of one project to another should be considered carefully, so that the learning experience in one project could enhance the work of another. Thus a project on, for instance, magnetic films for computer disks bears very little relation to one on fiber-epoxy reinforced composites.
6. The time for realization of a given project should be very carefully examined. It is counterproductive to make promises that cannot be realized. On the other hand, it is important for obtaining support that one or two of the initial projects show enticing results within about 3 years.
7. Plans should be carefully written and should identify, right from the start, goals and times for realization of each step of the project.
8. Additional manpower and management expertise must be added from internal and external sources, so that the current ONDE program does not suffer.
9. The program should be built fairly quickly from the first project on automated production metal powder up to two or three projects. Then, based upon this experience, if successful, several more projects could be added.

Conclusions

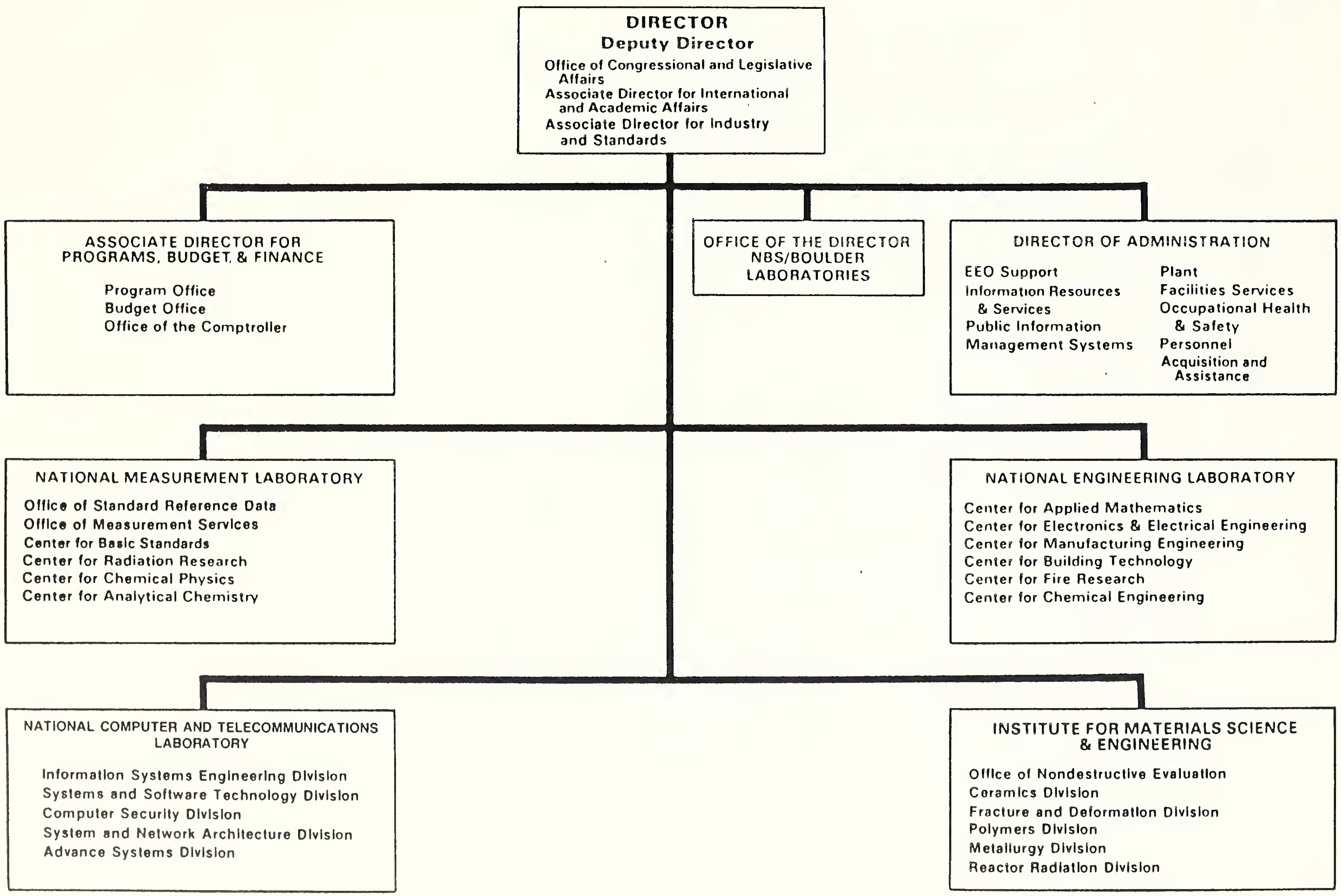
The Panel was very pleased with the progress in the nondestructive evaluation work at NBS. The Office is showing real leadership in the proposed new initiatives in automatic processing, and these plans should be encouraged. The organizational structure of ONDE is likely to be inadequate to run programs of this kind. Consequently, reorganization may be required to (1) facilitate the necessary participation of other segments of NBS (e.g., Center for Manufacturing Engineering, Center for Electronics and Electrical Engineering, Institute for Computer Sciences and Technology) and (2) provide the needed systems design and analysis component in the management of the program.

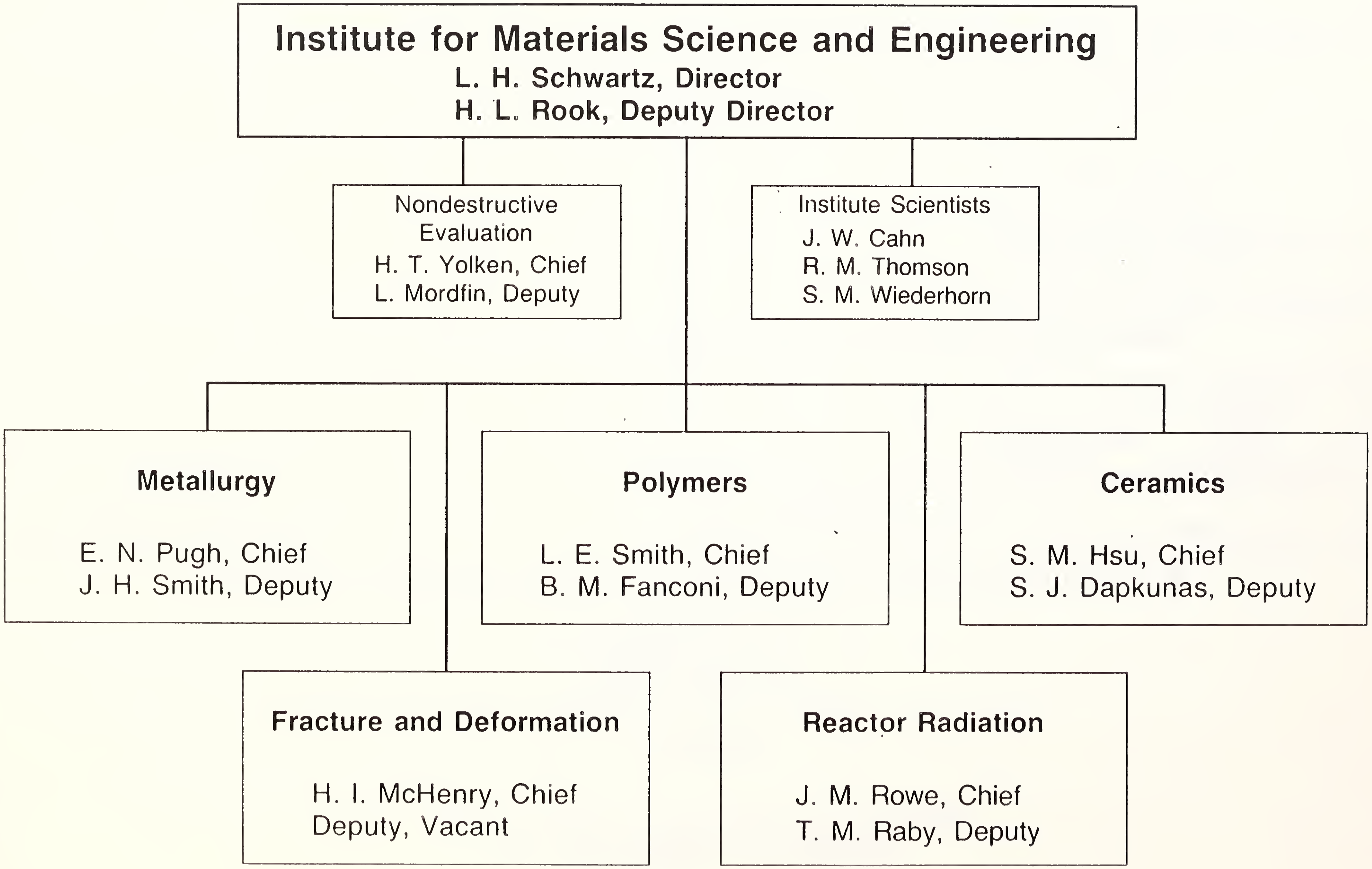
ONDE, like much of the rest of NBS, has been working with a constant dollar budget for several years. In the opinion of the Panel, it is most desirable to increase the financing of this Office because of the great importance of their current and proposed work to improve manufacturing efficiency in this country.

NIST AND IMSE

ORGANIZATION CHARTS

U.S. DEPARTMENT OF COMMERCE
National Institute of Standards and Technology




Institute for Materials Science and Engineering
L. H. Schwartz, Director
H. L. Rook, Deputy Director
Nondestructive Evaluation
H. T. Yolken, Chief
L. Mordfin, Deputy
Institute Scientists
J. W. Cahn
R. M. Thomson
S. M. Wiederhorn
Metallurgy
E. N. Pugh, Chief
J. H. Smith, Deputy
Polymers
L. E. Smith, Chief
B. M. Fanconi, Deputy
Ceramics
S. M. Hsu, Chief
S. J. Dapkunas, Deputy
Fracture and Deformation
H. I. McHenry, Chief
Deputy, Vacant
Reactor Radiation
J. M. Rowe, Chief
T. M. Raby, Deputy

FUNCTIONAL STATEMENT

INSTITUTE FOR MATERIALS SCIENCE AND ENGINEERING

Develops and maintains the scientific competences and experimental facilities necessary to provide the Nation with a central basis for uniform physical measurements, measurement methodology, and measurement services fundamental to the processing, characterization, properties and performance of materials, and to other essential areas in materials science; provides government, industry, universities, and consumers with standards, measurement methods, data, and quantitative understanding concerning metals, polymers, ceramics, composites, and glasses; characterizes the structure of materials, chemical reactions, and physical properties which lead to the safest, most efficient uses of materials; improves materials technologies, provides the bases for advanced material technologies, in basic and high-technology industries, and encourages recycling; obtains accurate experimental data on behavior and properties of materials under service conditions to assure effective use of raw and manufactured materials; provides technical information such as reference data, materials measurement methods, and standards to processors, designers, and users for selection of cost-effective combinations of materials, processes, designs, and service conditions; uses the unique NIST reactor facilities to develop neutron measurement methodology, develop sophisticated structure characterization techniques, reference data, and standards; participates in collaborative efforts with other NIST organizational units in the interdisciplinary developments in materials science; and disseminates generic technical information from the Divisions to private and public sector scientific organizations through special cooperative institutional arrangements and through conventional distribution mechanisms.

NBS-114A (REV. 2-80)

U.S. DEPT. OF COMM. BIBLIOGRAPHIC DATA SHEET (See instructions)	1. PUBLICATION OR REPORT NO. NISTIR-88-3845	2. Performing Organ. Report No.	3. Publication Date December 1988

4. TITLE AND SUBTITLE

IMSE Annual Report, 1987

5. AUTHOR(S)

Lyle H. Schwartz

6. PERFORMING ORGANIZATION (If joint or other than NBS, see instructions)

NATIONAL BUREAU OF STANDARDS
U.S. DEPARTMENT OF COMMERCE
GAITHERSBURG, MD 20899

7. Contract/Grant No.

8. Type of Report & Period Covered

10/1/87 to 9/30/88

9. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS (Street, City, State, ZIP)

National Institute of Standards and Technology
Institute for Materials Science and Engineering
Gaithersburg, MD 20899

10. SUPPLEMENTARY NOTES

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

11. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)

The 1988 Annual Report was prepared for the NAS-NRC Board of Assessment of the Institute for Materials Science and Engineering. This volume contains background information on resources, activities, and representative highlights of the Institute.

12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)

activities; highlights; Institute for Materials Science and Engineering; National Institute of Standards and Technology; resources; review

13. AVAILABILITY

☐ Unlimited
[XX] For Official Distribution. Do Not Release to NTIS
☐ Order From Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
☐ Order From National Technical Information Service (NTIS), Springfield, VA. 22161

14. NO. OF PRINTED PAGES

15. Price

USCOMM-DC 6043-P80